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DWIGHT H. GREEN, Governor

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ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING
SPRINGFIELD, ILLINOIS

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PAPERS IN AGRICULTURE

FROM THE REPORT OF THE SECTION CHAIRMAN

Nine papers were presented at the Jacksonville meeting, eight of which are herewith published. The other was:

BADGER, C. J., *Meeting wartime production while maintaining fertility in southern Illinois.*

The meeting was attended by nineteen.

C. J. BADGER, Agronomy Department, University of Illinois, Urbana, was elected chairman for the 1943-44 meeting at DeKalb.

(Signed) O. L. WHALIN, *Chairman*

AGRICULTURAL EXTENSION PROGRAM MEETS WARTIME NEEDS

W. F. COOLIDGE

Farm Adviser, Morgan County, Illinois

INTRODUCTION

As early as 1836 the United States Government began to take an interest in the development of agriculture. In 1862 a Bureau of Agriculture was established as a part of the Department of the Interior. From then on, many bureaus were organized from time to time, agricultural colleges were sponsored by land grant aids and federal funds, and agricultural experiment stations were established.

The agricultural experiment stations have conducted scientific experiments in the interests of agriculture, horticulture, and dairy in every state and in the territories. They have experimented with fertilizers and soils, improved varieties of grain and fruits and also breeds of livestock, studied the habits and means of destroying noxious insects and investigated diseases of domestic animals and means for their prevention and cure.

Up to 1914 the local educational program was carried on by farmers' institutes, household science groups, and schools. Assistance has been given by men from the experiment station and the college of agriculture.

In 1914 the Smith-Lever Act was passed, giving the Extension Service the right to cooperate with the states and counties the opportunity to organize agricultural education agencies to be placed in charge of county agents or farm advisers. Later home advisers or home demonstration agents were added, and adult education for women was thus established in many counties. Funds were to come in part from the Federal Government, in part from the State, and in part from the county. In Illinois the cooperating agency is the Farm Bureau and the Home Bureau.

MORGAN COUNTY

During World War I the county farm bureaus were organized rapidly in Illinois. Morgan County was organized December 26, 1917, when the following purposes were outlined at the meeting of the executive committee:

1. To increase crop production.
2. To facilitate efficiency.
3. To raise better livestock.
4. To eliminate leaks in the business of farming.
5. To get acquainted and to get farmers acquainted with one another.
6. To work for better records.
7. To organize 4-H clubs for boys and girls.

The work progressed along these lines until the "great depression," when farmers were having a hard time to get adequate prices for their produce. At this time a program was worked out seeking improvement of conditions on the farm. Chief needs were more efficient crop rotations and a livestock program that would yield top-price livestock with a minimum amount of feed. Through the efforts of the agencies and helped by the Agricultural Adjustment Act the farmers started back to more normal conditions. Other helpful agencies developed at this time were the Credit Association, the Commercial Loan Company, the Federal Land Bank, and the Farm Security Administration.

EXTENSION SERVICE PROGRAM

The parent organization, the Extension Service, the oldest established agency and a strictly educational institution, continued its program of bettering conditions through concrete demonstrations on farms and through the experiments carried on at the experiment field, at the State University and the Experiment Stations. These demonstrations and experiments fitted into the agencies' program of agricultural improvement seeking profitable incomes for all farmers.

At the beginning of the war a 12-point program was developed, prime objective

of which was to keep the farmers informed not only regarding agriculture but also the affairs of the world and the war.

1 **Farm machinery.**—At the start of the war the farm machinery program was quickly seen to be vital to increased production. County surveys were made to see what machinery was available, what repairs were necessary, and what machinery could be obtained. Each farmer was urged to repair his machinery and to keep it in good repair so that it would last. This program did much to assist farmers in planting and harvesting their crops on time.

2 **Wartime educational program.**—The County Agent and the Home Demonstration Agent act as chairman and co-chairman of the county wartime educational program. A county committee of home makers and farmers met to decide on the program to be followed. The 208 chairmen and co-chairmen representing the 104 school districts have assisted in distributing information on the war, on soil improvement, crop improvement, machinery repair, animal disease control, inflation, and many other subjects that would assist farmers in better understanding what was going on.

3 **Labor.**—The chairman of each school district was also made chairman of the labor committee. He registered all farmers who needed farm labor in the area and also registered boys who were willing to work on farms in other localities. This information, handled through the Extension Service and the U. S. Employment Service, assisted many farmers in getting farm hands.

4 **4-H Clubs.**—A special effort was made to organize a 4-H Club in each community. Any boy or girl between the ages of 10 and 20 is eligible to become a member. Approximately 800 boys and girls are now enrolled in the 4-H clubs of the county, all contributing something to the war effort. One of the outstanding programs is the work program in which the boys and girls are given credit for their activity on the farm rather than for carrying out a particular project.

Boys and girls are also investing money in war bonds and are buying an ambulance.

5 **Soil improvement.**—The Extension Service has cooperated with the Soil Conservation Service and the A.A.A. in giving farmers more definite information on contour-farming and strip-cropping in order to save moisture and to save wear and tear on machinery. Through the Extension Service a free test of soil is given all farmers bringing their samples to the office, so that they will know how much limestone and rock phosphate are needed. Assistance has been given farmers in obtaining limestone from the best sources available. Limestone is purchased on its merit as to the percentage of calcium carbonate equivalent that it contains.

6 **Crops.**—Through the field tests carried out in the county we have been able to pass on to the farmers of the county the names and numbers of the best types of hybrid corn that can be planted. We are also experimenting on the crops that are resistant to various insects, such as the European corn borer, chinch bugs, root worms, and others. This information is compiled not only from our own county but also from our experiment stations and from the State experiment station.

7 **Gardening.**—Victory gardens are the result of much information being given the farm people on the planting, cultivation, and care of vegetables. Information available includes varieties of beans, peas, salad crops, and the vegetables that are the best producers, the most resistant to disease, and that can be best stored under the various storing conditions.

8 **Transportation.** — Information meetings have been held regarding conservation of transportation facilities with relation to getting livestock to market, thus saving rubber, wear and tear on trucks, and labor. In this way excess trips to markets are cut down.

9 **Disease control.** — Disease control methods are passed on to the farmer through the newspapers, meetings, over the radio, and in local publications.

10 **Insect control.**—From the State Entomologist comes information on the various insects that damage crops. Many inquiries are answered as to when to plant, what crops to plant, and what to do to prevent serious damage when the crop is growing. For example, there are three methods of combatting the European corn-borer—(1) carefully plow under all refuse; (2) plant corn that is resistant to the borer; and (3) plant late enough so that the early brood is out of the way.

Other insects that harm crops are the

chinch bug, grape colaspsis, cut worm, leaf hopper, grasshopper, Army worms, blister beetle, potato beetle, to mention a few. Methods of control, if properly applied, save much expense.

11 **Poultry.**—Poultry production is another program. Methods of feeding to increase production of eggs and meat as well as methods of controlling disease and parasites are given through the press, radio, and meetings. Plans are available for houses, brooders, and feeders, all of which may be built by the farmer at a nominal cost.

12 **War Board.**—The Extension Service is represented on the agricultural War Board and is active in discussions that have to do with agriculture.

Home Extension work.—The Home Extension work has as its long-time objective the home security through conservation of material resources on the farm in helping to win the war.

Since the war began, the county nutrition committee, with the county Home Adviser as chairman, has distributed health and nutritional information as well as teaching the various methods of food preservation such as canning, freezing, salting, and drying. The planting, use and preservation of more home-grown foods is encouraged by the home-grown health program. More than 1400 home makers have had instruction regarding the importance of better eating habits and better health, and the prevention of the common cold as related to nutritional practices.

Since prices have risen, more home sewing is being done. Home makers are being taught that care and repair of their present supply of clothing is important in the saving of fabric and textile supplies, all in line with the war effort on conservation.

In the last analysis, there is no phase of the agricultural educational program or the home makers program that is not being presented to more than 2,000 farm families in the county by the Extension Service. The Extension program may not have definite information nor specific examples to answer all questions but it is ready and willing to help whenever possible. The program will certainly help to win the war and to do a better job in writing the peace.

The sole aim of the Extension Service in the county is to give to the adults and to those not in school information that will help them, that may be used in a practical way, and that will have a lasting influence on the future development of agriculture in Morgan County.

WOOD HELPS WIN THE WAR

J. E. DAVIS

University of Illinois and State Natural History Survey, Urbana
Chairman, Illinois Wartime Timber Marketing Committee

In a state so intensively agricultural as Illinois probably the great majority do not realize the key position taken by wood in the pursuit of our war program. Even the three million acres of Illinois woodland—only nine per cent of the area of the State and less than 0.3 per cent of the farm woodland area east of the great plains—is so important to the war effort that special measures are being taken to increase production of our native timber and to maintain operation of the State's 1,000 wood-using industries.

It should be enlightening to review some of the facts of the utilization of wood in the war. During 1942, about 90 per cent of the lumber produced in the United States went to the war effort. There are more than 1,200 different items of military and naval equipment that can use lumber. Add to this the paper and wood for packaging lend-lease, quartermaster and ordnance supplies, and domestic lumber demands for agriculture and war industries, and a total consumption of more than 38 billion board feet is built up. In 1941, before the heavy war demand, it took more than 36 billion feet to approximately meet our requirements.

Figures on the war requirements for strategic materials are usually rather closely guarded secrets but early in 1942 some figures were released that will give an insight into the rôle of wood in war now that our war effort is in full swing.

More than 200,000 defense housing units have been built, representing housing capacity sufficient to take care of the combined populations of cities the size of Madison (Wisconsin), Fort Wayne (Indiana), and Grand Rapids (Michigan). Housing for soldiers in army camps requires 1,000 board feet per soldier for tent camps and about twice that amount for barracks. Many of the larger cantonments have required 20 million board feet of lumber each.

It has been estimated that lend-lease required nearly 10 billion board feet of lumber in 1942. How can so much lumber be used for this one phase of the war effort? We have some information on a few lend-lease items for 1941 that will show how lumber and other forest products are consumed in such shipments.

The 1941 shipments of poultry and eggs required 90 million board feet of lumber, 360 million square feet of veneer, and 500,000 tons of paper and fiber board.

Dairy products used 74 million board feet of lumber, 2½ billion square feet of veneer, 60 million barrel staves, 5 million butter tubs, and 400,000 tons of paper and fiber board.

Fruits and vegetables used 1½ billion board feet of lumber, 3 million square feet of veneer, 46 million barrel staves, and 102,000 tons of paper and fiber board.

These figures cover only a few lend-lease items, and are for a period when we were far from the height of lend-lease shipments and had not yet established armies on the world battle fronts which have to be supplied primarily by shipments from home. There are no more recent figures available, but it is easy to imagine something of the increase of supply packaging problems since 1941.

The packaging of supplies for war export is not the simple matter of loading ships with foodstuffs in the packages we are accustomed to seeing in our local groceries, or with uncrated machines as we have often seen rolling over the railroads on flat cars. War export items must be packaged virtually water-tight and in packages substantial enough to withstand the roughest conceivable handling conditions. Particularly in the servicing of invasion armies it already has proved necessary to dump the entire supply into the surf later to be gathered on the beach or to be dragged in by cables from winches on shore. Such problems multiply the lumber, paper, and fiber board used for war shipments many times over that used for similar items in peace time.

War industries have been enormous consumers of wood products and their

demands are increasing. This is due to the direct use of wood in war items, the substitution of wood or wood products for critical metals, and the use of wood in crating, car bracing, and dunnage. In the case of ammunition, there are more than 80 different types of shell boxes used for the purpose of retransport. In this and in many other types of ordnance items various parts are sub-contracted to scattered manufacturers and are then brought together at one assembly point. These parts, many of them of delicate precision, must be packed mostly in wooden containers to go to the assembly plant.

More than 100 articles normally made of metals can be replaced by wood, and the limits of such substitutions are unknown with the new developments in plywood and wood plastics. It is expected that most of our trainer planes and probably the proposed huge freight planes will be built largely of wood. Already, the molded plywoods have proved their worth even in battle planes. The newly developed compregnated wood offers strength, hardness, and water resistance equal to some of the metals.

Going from the air to the sea, waterfront developments for 1942 were estimated to require 55 per cent more piles than were used in the average for the 1936-40 period. Wooden ship building has had a tremendous revival. Many types of the smaller boats are satisfactory if built of wood, and this use of wood releases steel for its more urgent use in combat vessels. White oak is the most commonly used wood for shipbuilding, and high-grade white oak is now so badly needed that by order of the War Production Board it is illegal to manufacture white oak into furniture veneer or to sell logs for this purpose. Even the great "battle-wagon" which appears to be all-steel is a heavy user of wood, for half a million board feet of lumber go into the armored steel battleship.

Actually, these are comparatively few uses of wood in the war effort, but I want to turn particular attention to the place of Illinois-grown wood in the war program. Probably the most important use of wood for the war in this state is the meeting of domestic requirements in the production, packaging, and shipping of agricultural products.

There is always an active construction program under way in rural Illinois in the maintenance and replacement of farm structures, and a vastly expanded production program meant more construction for the expansion of housing facilities. Although the building limits permitted for farm construction have been fairly liberal, many farmers have found it difficult to obtain buildings adequate to meet the needs of their production capacity. Here Illinois woodlands come into their own. There is no farm construction need that cannot be filled by some native wood. It did not take farmers long to realize that native lumber from their own woodlands at a cost of twenty dollars a thousand board feet would make a lot more building for 1,000 dollars than could be built with finished lumber at seventy or seventy-five dollars a thousand. So far as the application of native woods to farm construction jobs is concerned, its limitation depends only on the ingenuity of the builder. I recently had a report of a corncrib built entirely of willow. Willow could hardly be considered a construction timber, but willow was the only timber available, and it was made to serve the purpose.

Probably more houses were built for farrowing sows this year than ever before in Illinois history. However, the increase in hog houses was not in proportion to the increase in hogs, and it is admitted that part of the heavy pig losses this spring were due to chilling because of inadequate housing. More attention will have to be turned to proper housing in another farrowing season. The old gooseberry bush down in the timber just won't do for a farrowing house in weather like we have had this spring. Green, rough lumber cut from a few of the trees down in the timber will make good hog houses, and at low cost.

Fence posts, fence boards, gates, machinery repair parts, wagon parts, eveners and implement handles are a few other farm items for which home grown wood may be used. I did not place fuel wood in this list because it requires special consideration. Coal has been abundant and cheap in Illinois and but few have made a practice of burning wood for heating or cooking. I have repeatedly warned that we may face a fuel shortage in the winter of 1943-44 and wherever supplies are available wood should be used for fuel.

Even if a serious shortage does not occur I feel that anyone who has wood and wood-burning equipment available is not justified in creating an extra drain on transportation by demanding other fuels. Wood is good fuel. A standard cord of oak and hickory has more heating value than a ton of the average Illinois coal. Illinois woodlands could produce enough firewood annually to replace a million and a half tons of coal.

I must skip over the containers for marketing and storage of the agricultural products. This use includes baskets, boxes, crates, trays, cases, and bins. Just this week I have been in southern Illinois studying the basket and box situation for fruits and vegetables. There is a definite shortage of fruit and vegetable containers which, if not corrected, will hamper the production of food for the war effort. These containers, manufactured by eleven concerns in Illinois and several others in adjacent states, are made entirely of wood from our farm woodlands.

Some special war items deserve particular attention. Outstanding of these is black walnut which is used for gunstocks and airplane veneer. The walnut timber crop is so important in Illinois that a survey of walnut owners has recently been completed and an inventory of the walnut resources is now being made. There are over thirty black walnut buyers now active in Illinois purchasing trees and logs for war use. It is estimated that more than 25 million board feet of black walnut went into war use in 1942.

Another special item is dogwood. Dogwood is used for shuttle blocks for the textile industry which, in turn is indispensibile to the war program. This industry was facing a critical shuttle shortage until steps were taken to bring about the marketing of more dogwood. Twenty thousand cords of dogwood are being harvested from the national forest in southern Illinois for this purpose.

In the Peoria area a paper mill has recently started using native woods for paper manufacture. Inferior species and cull material from woodland improvement cutting are used so that all classes of timber find their place in war production.

The heavy machine manufacturerers of Peoria, Rockford, and Chicago are turning to the use of native woods for crating, skid timbers, and car blocking. These industries as well as the paper mill were in existence and were using wood before the war but they used wood shipped considerable distances. The importance of current trends lies in the lessening of the drain on transportation facilities and the release of softwood lumber for other war uses.

Going back to the over-all lumber situation, the 1942 total lumber production fell some 4 billion board feet short of meeting war and essential civilian requirements. Lumber production in Illinois started dropping off in the fall of 1942 and by January 1943 was more than fifty per cent below September 1942. Since January, there has been a slight increase but not sufficient to meet demands. Early in 1943 the various agencies concerned with forest production in Illinois organized the Illinois Wartime Timber Marketing Committee. The objectives of this group are to coordinate the production efforts of the member agencies and to pursue an active program designed to increase and maintain lumber production. The fruit and vegetable container study previously mentioned is one of the projects of this committee.

More recently the War Production Board and the United States Forest Service have proposed a program patterned on similar lines.

This state and national attention to lumber production is indicative of the key rôle wood plays in the war. Lumber is listed with steel, aluminum, and copper as a critical war material. Shortages of lumber and other forest products threaten to impede seriously our war effort. Wood helps win the war, but every day that wood production lags behind war needs, just so much longer is the day of final victory postponed. I believe that the problems can be overcome and production brought nearly up to schedule, but it is up to every individual, as well as the foresters and lumbermen, to understand the place of wood among other critical war materials. Only then can we achieve the most effective use of our forest resources.

RURAL WAR PRODUCTION TRAINING PROGRAM

R. D. EILER

Jacksonville High School, Jacksonville, Illinois

In one respect I believe we will all agree—and that is we all deplore this or any other war in which our country is involved. However much this may be true, the fact remains that great technological and educational advancements usually develop from wars. Just as the Land Grant College movement was precipitated by the Civil War, and the Smith-Hughes law came about during World War I, so has our present Rural War Production Training Program, commonly referred to as O.S.Y.A. (Out-of-School Youth Administration) been expedited by our present conflict.

Our country is now launched upon the greatest food-production program in the history of the world. In an effort to help farmers solve their food production problems, the 77th Congress of the United States called upon the public high schools for assistance. Public law No. 647 was passed by Congress which provided for certain vocational courses of less than college grade for out-of-school rural people. The law states that the purposes of these courses are as follows:

1. To acquaint farmers with the methods of achieving production goals of those farm commodities designated by the Secretary of Agriculture.
2. To better qualify persons to serve agriculture as it becomes increasingly mechanized.
3. To aid farmers in the repair, operation, and construction of farm machinery and equipment.

Twenty different courses have now been set up and authorized by the Secretary of Agriculture as follows:

1. The operation, care, and repair of tractors, trucks, and automobiles.
2. Metalwork, including welding, tempering, drilling, shaping, and farm machinery repair.
3. Farm woodworking—not including cabinet work, model or furniture making.
4. Elementary electricity, including operation, care, and repair of electrical equipment, and wiring for light and power.
5. The repair, operation, and construction of farm machinery and equipment.

6-20. Increasing production of milk, poultry, eggs, pork, beef, mutton, lamb, wool, soybeans, peanuts, commercial vegetables, fruit, hemp; the production, conservation, and processing of food for farm families; and the training of farm labor.

Courses 1-4 above are now being offered for the third consecutive year—the first two years as courses available for out-of-school youth from ages 17-25. The other courses are new this year and have been made available for any out-of-school person over 17 years of age.

This year the quota for Illinois was set at 2000 different courses. All of the 385 departments of vocational agriculture throughout the State were urged to sponsor six or seven of them. At first this figure seemed inconceivable to everyone but they have succeeded admirably and the latest figures show close to three-fourths of the goal achieved with almost two months until the final date for applications July 1st.

The federal law placed the responsibility of administering the program in Illinois upon the division of the State Board of Vocational Education. The administration of the program in local communities has been the responsibility of the local high school administrators with the help of vocational agriculture teachers. In spite of their greatly increased duties in other war activities these men gladly accepted the added responsibilities. A new concept of the possibilities of vocational agriculture is entering the consciousness of school and government officials as a result of the success which has attended the efforts of teachers of vocational agriculture. The law provided however that courses could also be set up in schools not having agriculture departments.

The interest of farmers throughout the State has been most surprising to school men, in fact many cases are on

record in which the number of farmers desiring to enter the courses has far exceeded the local facilities. The success of this program in large part has been due to the desire on the part of farmers to accomplish all they can to supply the great demand for food, and they are taking advantage of the opportunities which this program offers for the repair of their farm machinery, to repair or build equipment needed for their expanded program of livestock production, and to study and learn all they can about methods of food production so that they may achieve maximum results.

The task of realizing all of the expectations of the Secretary of Agriculture in this phase of the "Food for Freedom" program was placed squarely up to the teachers of agriculture. In a letter to the Commissioner of Education Mr. Wicard said:

> "It is my hope that the 9000 teachers of vocational agriculture will include the *Food For Freedom* program in their plan of work for this year."

The teachers to whom the Secretary referred I believe have universally accepted and are gladly meeting this challenge.

Using the program offered locally by Jacksonville High School as more or less a typical example of what is being done by hundreds of schools throughout the State and nation, it is of interest to note that the program was begun November 3, 1942, with a course in gas engine repair and one in farm woodworking. December saw the start of a discussion group on soybean production in a rural grade school followed by another in January on pork production held in the vocational agriculture classroom of the high school. Each discussion group was preceded by the establishment of an advisory council who chose the topics and determined the policies throughout the courses. A group of six or seven farmers seems to be about the correct number. The teacher of agriculture gave instruction in both courses but additional courses of the same type would have had to be taught by someone else. In January began a second woodworking course taught by the manual arts teacher and also two farm machinery repair courses handled by mechanics. Another very popular course held during January and February was the course in welding, given in one of the local machine shops. Just now a course in preservation of food for farm families is being offered in the home economics department by the local teachers of home economics, and this will be followed by two canning courses later in the summer making a total of 11 for the year. An approximate expected enrollment of 225 persons will have been enrolled with a federal cost of approximately $12.00 per capita.

Following the federal requirements the gas engine, woodworking, and welding courses met three hours per night, five nights per week for a period of eight weeks or a total of 120 hours each, while the farm machinery courses met on five consecutive days, putting in a total of 36 hours for the week. Discussion groups including the food preservation courses met two hours per night one night per week for 10 consecutive weeks or a total of 20 hours. The canning courses will meet four hours each morning for five consecutive days.

The entire program has been characterized by a fine spirit of cooperation on the part of the Board of Education in offering the facilities of the school plant, the garages, machine shops, the farm machinery dealers, the instructors other than the agriculture teacher, the school administrators, the Farm Bureau, the Farm Adviser, other agricultural extension representatives, local veterinarians, janitors, high school office secretary as clerk, local merchants who obtained needed supplies, and many others who were involved in various ways. Local newspapers, radio station, and county war board gave adequate publicity, and the program could not have been other than successful with all of these willing agencies.

As to the future of the program it will undoubtedly continue, with minor changes, for the duration of the war. It is well within the realm of possibility that it may even assume permanent proportions afterwards. I should like to point out a few possibilities which could accrue from the start which has been made. First, opportunities for the study of agriculture will, before many years, become nearly universal. Second, the communities which now have departments of vocational agriculture but which have confined their services to a few farm boys of high school age, will make them available to people generally.

Third, since the Federal Government has taken the initiative in providing agricultural education for the "masses" through the medium of public schools, we can except that our example will be imitated more widely in other countries after the war. May this influence and leadership be of the best quality. Fourth, the future program will probably provide for education along agricultural lines other than farming. Fifth, it will undoubtedly provide more guidance regarding agricultural occupations as well as the training of adults toward that end. Sixth, it is predicted that enrollments will be large, frequently requiring the services of more than one teacher. Seventh, the enrollment in vocational agriculture may be largely adult. There are ten times more adults to be reached than high school boys. Eighth, there will be much more attention to objectives and to evaluation of courses in terms of objectives. Ninth, programs will be more carefully planned with the assistance of advisory councils representative of the community. Tenth, and last, public school education in agriculture will be more closely correlated with other related agencies such as the agricultural extension service, with the schools usually taking the initiative in bringing about this coordination.

There is no good reason why agricultural education should not share in the planning of the post-war world as it can make an important contribution to the "freedom from want" philosophy. The responsible leaders of farm people will have much to do with the attitude farmers take toward world problems. Our American farmers may make or break any effective arrangement for world organization which is proposed. Such may well be the immediate and eventual results of our present Rural War Production Training Program.

MAKING PASTURES PRODUCE THEIR SHARE OF FOOD

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Pastures are playing an important rôle in the wartime food production program, but they can be made to take an even greater part by increasing the output of livestock products.

During and after the last war, production was measured largely in terms of wheat, corn, and other cultivated crops. Consequently, a high percentage of our pasture land was plowed. Today we recognize much better the production and conservation value of pastures in the farming system.

Illinois has more than 8,000,000 acres of permanent pasture. In addition, several million more acres now being cultivated should be in permanent pasture if they are to be saved from destructive erosion. It is estimated that the production of forage could be doubled on at least 50 per cent, or 4,000,000 acres, of pasture land. A large portion of the land now in grass was cultivated during the last war or at some time during the last 100 years. In many cases, constant farming and soil erosion had severely reduced the productive capacity of the soil before it was "retired" to pasture.

Permanent pastures can be classified into three groups on the basis of their productivity—high, medium, and low. It is recognized that some soil types produce forage crops much better than others. However, the high-producing pastures are found on fertile soils that have been limed, fertilized, and seeded to legumes or have received applications of barnyard manure. These soils are fertile mainly

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because of their inherent productivity or because of the treatment they have received, or both.

Pastures that fall in the low-productivity group have generally received no soil treatment and little, if any, controlled grazing. The grass on these areas is grazed closely the year around. Root reserves cannot be maintained under these conditions and gradually the grasses are killed out. Weeds then grow up to replace the perennial grasses, and forage production goes downward. Such weeds as ragweed (*Ambrosia artemisiifolia L*), blue vervain (*Verbena hastata L*), broad-leaved plantain (*Plantago major L*), crabgrass (*Digitaria sanguinolis* Scop.), daisy fleabane (*Erigeron annua* L), and many others are quite common in pastures of this type. The carrying capacity of highly productive pasture averages 1.5 acres per animal unit for the grazing season, in contrast to 3 to 6 acres per animal on pasture of low productivity.

There is considerable acreage of wooded pasture in the low-productivity group. Experimental records show that it requires 6 acres or more of wooded pasture to furnish sufficient forage for one full-grown cow, or one animal unit. A study made by the Soil Conservation Service in cooperation with the University of Minnesota shows the variation of yields between open pasture and woodland.

TABLE 1.—180-DAY PASTURE PRODUCTION TESTS, SOUTHEASTERN MINNESOTA
(12 plots on each of four farms)

Year	Renovated	Open	Wooded
Tons per acre 15 per cent moisture			
1938....	3.43	2.12	0.31
1939....	1.70	1.03	0.26
1940....	2.05	1.10	0.32
Acre per cow			
1938....	0.7	1.1	7.0
1939....	1.3	2.2	8.5
1940....	1.1	2.1	6.9
Per cent protein			
1938....	—	—	—
1939....	15.0	16.1	12.0
1940....	15.6	15.8	11.0

An analysis of the grasses growing in the timber indicates that they are very low in nutritive value. The leaves of many plants and trees growing in wooded pasture are poisonous to livestock. Every year white snakeroot, alone, kills livestock worth thousands of dollars.

Pastures on which soil treatment, grass-legume mixtures, and grazing control are used will give favorable comparative returns. An Ohio study, the results of which are reported in Ohio Bulletin No. 154, compared the production of improved pastures to the production of corn, wheat, and clover rotated at 34 to 43 locations for 3 years. The following results were obtained:

Three-year rotation
Corn, wheat, clover

It cost $20.68 to produce 5,397 pounds of dry matter per acre containing 408 pounds of protein equal to 11 bags of linseed meal. Total value $27.50.

Improved pasture
Fertilized, reseeded

It cost $11.59 to produce 5,084 pounds of dry matter per acre containing 578 pounds of protein equal to 15.6 bags of linseed meal. Total value $39.00.

The results indicate that we can produce more protein from a well-managed pasture than from a corn-wheat-clover rotation and at approximately one-half the cost of production. There doubtless will be a shortage of protein for the duration of the war, which makes it doubly important that we look to pasture crops to help make up this shortage.

Five simple steps are recommended for the improvement of permanent pastures. They are given in University of Illinois mimeographed circular entitled, "Five Steps in Pasture Improvement" as follows:

1. **Test the soil for acidity and phosphorus and apply the treatment in the amounts indicated by the test.**—Limestone has gradually leached out of our soils making them slightly acid. In order to grow legumes and most grasses successfully we need to apply sufficient limestone to decrease the hydrogen ion concentration of the soil to Ph 6.5 or nearly neutral. Through soil erosion and the production of livestock and crops, phosphorus has been greatly reduced in many areas of pasture. A soil test will indicate the approximate amount of available phosphorus per acre.

2. **Disk the ground thoroughly in the late summer, on the contour, if possible.**—Contour disking on rolling land will help to hold the seed and soil treatment in place. It will also help to conserve moisture which can be used by the new seedlings. The disking should be done sufficiently early to give the limestone time to correct the acidity. Harrowing the field and finally rolling will prepare the seedbed for the new seeding of grasses and will compact the soil to aid the grasses present to reestablish themselves.

Disking for pasture renovation is preferable to plowing because by this method the pasture grasses already present are not destroyed and on rolling land there is much less danger of loss by erosion.

3. **Seed heavily.**—Sweet clover could be used as the main legume. If there is danger of the sweet clover weevil destroying the new seedlings of sweet clover, the addition of alfalfa, alsike clover, lespedeza, or red clover is advisable.

If a fair stand of grass is already present, the sweet clover alone is sufficient if weevil is not present. If the seedbed was prepared the previous fall, the sweet clover can be seeded at the rate of 10 pounds per acre in the late winter or early spring without working the soil further. Freezing and thawing in late winter or early spring will cover the seed. In cases where the stand of grass is thin some grass seed should be sown, preferably when the land is disked in the fall. Where a mixture of grasses and legumes is necessary, it is generally advisable to sow the grasses in August or September and the clover early the following spring. In seeding grasses in southern Illinois, use 4 pounds each of timothy, redtop, and orchard grass. In central or northern Illinois, sow 4 pounds of timothy per acre.

It is desirable to have both first-year and second-year sweet clover growing simultaneously in a pasture. This may be accomplished by making a second seeding of sweet clover a year later than the regular renovation seeding.

4. **Control grazing.**—The newly improved pasture should not be grazed until after July 1 the first year in order to allow the new seedings to become established. Grazing should only be moderate the first year and should be discontinued after September 15 in order to allow the plants to make some reserve growth for winter.

Grazing during the following years should be limited sufficiently so that a reasonable top growth can be maintained throughout the year. If more than one pasture is available, a system of rotation grazing can be used to good advantage. A system of rotated grazing will tend to increase the production of the pasture. It also gives the pasture grasses a chance to recover.

At the Dixon Springs Experiment Station, a fertilized pasture that was moderately grazed returned an average net gain of 144 pounds per acre in sheep for a 4-year period 1939-43, while a similarly treated pasture, which was overgrazed, returned an average net gain of only 12 pounds per acre.

Where sweet clover or some biennial legume is used there is a problem of management in maintaining it year after year. In order to maintain a biennial legume, care must be exercised to allow it to set seed every year. This can generally be accomplished by removing the livestock when the plants begin to bloom and keeping them out until the seed is set and the seed pods begin to turn brown.

Rotation or temporary pastures of clover, sudan grass, small grain, and alfalfa can be used to supplement the permanent pastures to good advantage. Used in the early spring or during drouth periods, these pastures will help to prevent overgrazing on permanent pastures.

5. **Weed control.**—Good growths of legumes and grasses on improved pastures will help to control the weeds. Since animals graze the more desirable plants, however, weeds tend to gain an advantage. Therefore, it is desirable to clip the weeds once or twice a year. It is generally desirable to mow when the largest portion of the weeds are in full bloom.

The grassland should be clipped 8 to 10 inches high so that the maximum use can be made of the grasses and legumes growing there.

If pastures are to be made to contribute their share of food production during and following the war, a program of intensive education of all the people who own or operate land is essential. A pro-

gram of conservation-production will be used on a majority of our farms only when a majority of the people appreciate the extent of the problem and have a knowledge of the necessary procedure in its solution.

In order to accomplish this task there are two necessary major steps that are being taken. The first is general education, and the second is community action. For many years, the Illinois Agricultural Extension Service, through the Farm Advisers and Extension specialists, has taken the leadership in carrying out a general education program in pasture improvement. Pasture management as a part of a course in conservation is being used by some of our colleges and high schools.

Many fine examples of community action can be found in the soil conservation districts organized by farmers in Illinois. Community leaders call together their neighbors for a round-table discussion of their community conservation problems. At these discussions it is generally recognized that a complete farm plan for the entire farm is the ultimate goal. This plan usually includes the crop rotation, the hay and pasture management program, and livestock system, grass waterways, drainage, contour farming, terracing, woodland and wildlife management, or a combination of any of these phases that will fit the farm and its effective operation.

In wartime, however, when labor, equipment, and materials are not plentiful, only those practices requiring the least, if any, additional labor, and that go the farthest toward food production, are started. Of these, contour farming, grass waterways, pasture production, and land drainage are the chief considerations. In the Morgan County Soil Conservation District, community leaders assisted by W. F. Coolidge, Morgan County farm adviser, and C. H. Krusa, assistant soil conservationist from the Soil Conservation Service, have conducted many group discussion meetings this past winter. The members agreed at each meeting as to the approximate amounts of pasture improvement and other production practice work they would try to accomplish this spring. The farmers usually plan to lime and reseed 10 to 20 acres of pasture each year and to practice grazing management on all of it.

In conclusion, I would like to say that the pastures in Illinois can be made to produce a greater share in the food production program than in previous periods.

The program of pasture improvement includes the application of the necessary limestone and plant food materials. This should be followed by the proper seedbed preparation and a heavy seeding of grasses and legumes. The production in the years to follow will largely depend on the grazing management and weed control program.

Rotation supplemental pastures of clover, small grain, or sudan grass can be used to relieve the permanent pastures.

A shortage of protein feeds for the duration of the war makes it highly essential that we depend on improved pasture to increase the production of livestock.

IMPROVING THE QUALITY OF ROUGHAGE AS AN AID TO WARTIME FEEDING OF DAIRY CATTLE

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Wartime demand for increased production of animal food products has caused an acute shortage of protein feeds. During the winter feeding season of 1942-43, suitable protein supplements were sometimes unobtainable by dairy farmers as well as by the feeders of other classes of livestock. It is likely that a similar condition may continue throughout the war period. What procedures can the dairy farmer follow to reduce the need for protein feeds and still maintain a high level of milk production?

One of the answers to this question is that improving the quality of the roughage part of the ration will not only increase the amount of protein which the roughage contributes, but will also furnish (a) more total nutrients (through increased consumption of more appetizing feed), (b) more vitamins, (c) more minerals, and (d) will enchance the thriftiness of the animal.

Increasing the fertility level of the soil is one of the effective ways of improving the protein content of forages. In experiments conducted at the University of Illinois, it was found that heavy applications of barnyard manure to bluegrass pastures during four consecutive years not only more than doubled the yields of dry matter, but increased the protein content to such an extent that the yields of protein from the fertilized plots were nearly three times as great as from the unfertilized areas. The percentage of protein in the fertilized forage was about one-sixth higher than that in the forage from the check plots. In subsequent experiments it was found that samples of forage harvested at monthly intervals from bluegrass plots heavily fertilized with a nitrogen fertilizer during four seasons contained 17.6 per cent protein in the dry matter, while forage from an untreated plot contained only 12.1 per cent protein. Applying these results to feeding practice, it means that a satisfactory supplement to well-fertilized pastures which supply ample forage may consist of a mixture of ground farm grains without the use of any high protein feeds. It also means that nitrogen fertilization of grass meadows will enhance the protein content of hay crops and thus lessen the need for purchased protein in winter feeding.

Fertilization also increases the protein and mineral content of corn. Snider reports these differences in the protein content of corn grown recently on the Morrow plots at the University of Illinois: 4.5 pounds of protein per bushel of grain from the plot planted continuously to corn without soil treatment since 1876; 6 pounds of protein, or one-third more, per bushel of grain from plots used in a corn-oats-clover rotation and treated with manure, lime, and phosphate. Even the stalks and cobs from the fertilized areas were higher in protein and mineral.

Higher quality hay than is usually produced can be made by (a) harvesting at an earlier stage; (b) using greater care in conserving leaves; and (c) using forced ventilation to remove excess moisture after the hay has been placed in the mow.

Red Clover in Illinois is commonly harvested for hay after one-half to two-thirds of the heads have turned brown. At this stage the hay is usually dark colored (low in carotene), stemmy, and relatively low in protein. These conditions can be corrected to a considerable extent by harvesting at the half-bloom to full-bloom stages and before the heads turn brown. It is likewise true of most other hay crops that early harvesting aids in the production of a more leafy, higher-vitamin, and higher-protein roughage.

The leaves of hay contain from two to three times as much protein per pound as the stems. Practices which aid in saving leaves are (a) windrowing soon after mowing, or at the time of mowing by the use of a windrower attachment;

(b) turning the windrows for curing only when the leaves are still sappy or the crop is damp from dew; (c) using well-designed and carefully-operated machines which pick up the windrow with a minimum loss of leaves.

Forced ventilation experiments at the University of Illinois have shown that air forced through cheaply-constructed wooden ducts on the floor of the hay mow by means a motor-operated blower will permit shortening of the field-curing period and storage of the hay while it still contains enough moisture for the retention of most of the leaves. Hay cured in this manner is higher in protein, mainly because of a greater retention of leaves, and is also higher in carotene levels and in palatability. The feeding of hay of this kind results in increased consumption and thus aids in reducing the needed amounts of purchased protein feeds. The feeding of four extra pounds of high-quality legume hay supplies as much protein as one pound of a protein supplement such as linseed meal or soybean meal. Increasing the quality of hay, therefore, means not only a higher protein content in the hay, but a much greater protein intake from the roughage portion of the ration because more of the hay will be consumed.

Harvesting of crops such as alfalfa and soybeans for silage to replace corn for this purpose is a further step toward the saving of purchased protein feeds. This procedure also has the advantage of making a better-quality roughage from these legume crops than can be done when attempts are made to cure them for hay under extremely adverse weather conditions. When legume silage is fed, the protein content of the grain mixture may be less to the extent of 1 to 2 per cent than when corn silage is fed.

[1]Snider, H. J., Feeding Value also Declines. Hoard's Dairyman, 88, No. 8, p. 250, 1943.

CUTTING CORNERS IN WARTIME LIVESTOCK PRODUCTION

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There are two main phases of the effort to cut corners in livestock production during wartime. First is the selection of feeds, which usually constitutes 60 to 85 per cent of the total cost of livestock production, and second is the labor.

SELECTION OF FEEDS

This year the supply of high-protein feeds is not equal to the demand. A generous use of pasture in summer and legume hay in winter helps very much to bridge this gap. Horses and colts, beef cow herds, sheep and lambs—all can be suitably nourished without purchased protein, provided they have good pasture or legume hay.

While young beef cattle being fattened respond well to the addition of a high-protein supplement to usual farm rations, they can nevertheless be fattened successfully without it if they have high-protein roughage. Cattle a year old or older fatten so well without additional protein that many successful feeders regularly give them only corn or other grains on pasture, or with clover or alfalfa hay.

The greatest problem is the hogs. Brood sows usually have somewhat stronger pigs if they receive one-fourth to one-half a pound daily of high-protein supplement during pregnancy, especially during the latter half of the period. Gilts have a greater need for this than do old sows. Some farmers now are breeding fall gilts to have their first litters in the fall when they are about one year of age. Thus these gilts have the favorable summer conditions during their first pregnancy. They will be older, more mature and better able to endure the less favorable winter conditions during their second pregnancy. Chester Heckathorn, LaSalle County, Illinois, uses this plan and fattens the sows for market during the summer after they have weaned their second litters.

Rye for pasture in winter and early spring provides protein and other factors which help brood sows go through the productive period with a minimum of other protein. Now since ceiling meat regulations have levelled off live hog prices to a large extent, there is little to gain by pushing early spring pigs for sale in early fall. Consequently there is now more of a tendency to breed sows for May and June pigs so that the regular permanent and rotation pastures offer their maximum support to sows during the nursing period. Such sows do surprisingly well with grain as the only other feed.

In these ways purchased protein may be practically eliminated from the rations of all meat animals excepting brood sows, pigs and young fattening hogs. Until they weigh 60 to 75 pounds, pigs respond so favorably to additional protein that most hog raisers attempt to supply it even during the pasture season. It is imperative for young pigs in winter. Without protein supplements in winter so many young pigs become unthrifty that few farmers would raise fall pigs.

Pasture for pigs gives best results if it is a legume crop such as alfalfa or clover, green and growing rapidly on fertile land. Pigs eat a maximum of such forage and it is high in nourishing value. At the University of Illinois, pigs weighing 51 pounds at the start of a test thrived so well on corn and good alfalfa pasture that they reached a weight of 200 pounds in 119 days, which was only 2 weeks longer than the time required for pigs fed corn and 0.27 pound daily of a mixture of tankage and soybean meal 2:1. In the two lots the same amount of total feed was required to produce 100 pounds of gain. This experiment illustrates the great value of good succulent pasture for pigs.

LABOR

Ingenious labor-saving schemes cut the corners in caring for stock on many farms. The water system may be simplified. A good spring, a well-behaved creek, or a drainage ditch offers a cheap source of water. Tile supplies water on many Illinois farms. An arrangement by Frank Stout, Sangamon County, is typical. He dug down to a big line of tile, replaced some of the tile with a concrete trough, put a grating over the trough to keep out the hogs, made a sloping rough concrete slab down to it, and hogs and cattle drink there most of the year.

In many parts of Illinois, ponds have been used successfully for many years by using an outlet pipe below the pond bank. The pond is fenced, and the water from the pipe flows into a trough or is regulated by a float the year around. Fire for warming the water in stock tanks is eliminated on many farms by locating the tank well back from the entrance in the livestock shelter and insulating it with a partial lid and a covering of horse manure.

Handling hay can be simplified. Ed Kinsinger, Livingston County, Illinois, uses a buck rake mounted on a tractor to supply hay to a 25-foot overshot stacker. Two men and a boy stack alfalfa hay in the field very rapidly with this outfit. One two-year-old 10-ton stack was hauled in which had only one-fourth of a ton of damaged hay. Hay is hauled to the cattle as needed. A storage barn cannot compete with that. And furthermore, hay can be safely stacked containing more moisture than is safe for barn storage. Stacks almost never catch fire spontaneously. Even if one did burn, it would not destroy a barn, too.

Oscar Linn, Fulton County, Illinois, stacks alfalfa in the field, hauls corn out there for the cattle and feeds them right there on about a 10-acre area around each stack. The manure is thus already spread for the following corn crop. One cuts corners in handling hay or fodder if it is taken to the feed racks the first time it is loaded and hauled. A big percentage of hay is saved on some farms by using feeding racks from which the stock do not get the hay out under their feet.

Moving corn is avoided on some farms by storing it in temporary cribs in the rotation pasture field where stock is to be fattened the next summer. Much labor can be saved by feeding whole grain and hay. It does not pay to grind corn for hogs, nor for cattle if hogs follow them to clean up the waste. Grinding hay does not pay unless it can be stored and fed more conveniently that way. Thorough mixing of grains and supplements does not pay if one may judge by the good results on farms where little mixing is done. It is not necessary for the stock to have each mouthful taste like every other mouthful.

Self-feeders save much work in fattening cattle and hogs. Some hog raisers and some lamb feeders scatter ear corn in the pasture with a manure spreader, and their success is first class.

In using the sanitation system for raising hogs some men reduce the work very much. They scatter the clean houses about two rods apart in the clean pasture field, wash all the sows at one time and turn them in to help themselves to houses, feed and water. These men raise about seven or eight pigs per litter, the same as farmers who work much harder in managing each sow separately.

How one can cut corners in fitting livestock into the farm plan has been shown by Herman Radue, Henry County, Illinois. He bought 46 steers the third week of April, turned them into a rotation pasture of timothy, red clover, and sweet clover, and fed them corn. On August 15 he added a high-protein supplement, and on October 10 he removed them to the drylot. He topped the market with them in Chicago on October 31. The same year in the same pasture, he had 28 sows from which he raised and sold 196 pigs. He had no hay, bedding, or manure to haul. The stock spread manure over the field ready for the next corn crop. He has made his farm steadily more productive by this labor-saving system.

Finally, in cutting corners in livestock feeding one should use pasture and legume hay as much as possible to balance the rations for any kind of livestock. This is very effective so far as it goes. Then one should shape his methods to fit in with the natural instincts and inclinations of the stock so that they work for the farmer instead of keeping him busy working for them.

SOIL DEPLETION REDUCES FEEDING VALUE OF CROPS

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It has long been known that a large portion of the soils in Illinois are deficient in available phosphorus. This deficiency was originally discovered by the fact that applications of phosphatic fertilizers to the land were often accompanied by substantial increases in crop yields. There are, however, some soils where there is no crop response to added phosphate, and such soils as a rule are well supplied with available phosphorus. Phosphate fertilizers in various forms have been and are still recommended and sold to the farmer solely on the basis that such fertilizers are profitable because of the resulting increased crop yield. Apparently up to recent years, there has been only limited emphasis placed on the desirability of adding additional phosphorus to the soil so that this in turn would add more of this important mineral to the feed of farm animals.

There is an increasing interest in the phosphorus content of crops grown on various soils. It has been discovered that some very serious livestock diseases may be traced directly to a phosphorus deficiency in their ration, and this in turn has been traced directly to a phosphorus deficiency in the soils over which the animals grazed or from which was collected a large part of their feed. The seriousness of this problem may best be illustrated by statements from men who are in close touch with various phases of agricultural problems.

Mr. G. C. Smith, Farm Adviser in Pope-Hardin counties in extreme southern Illinois, in his 1942 annual report states: "We have fewer reports of cattle breaking down in their backs since we have so many limed and phosphated pastures. Several years ago Doctor Walker had dozens of cases of cattle that went down in their backs. They were cured by an injection of calcium gluconate. The trouble was a lack of mineral in the feed, according to the veterinarian."

In an address before the 28th (1942) Annual Meeting of the Illinois Agricultural Association, Dr. W. L. Burlison said, "Chemical analysis indicates that the phosphorus content of crops grown on many of our light colored soils is now so low as to induce serious nutritional diseases in man and animals. It is a very significant fact that this phosphorus deficiency does not occur in forage crops grown on land which has received liberal applications of either rock phosphate or superphosphate."

Dr. T. S. Hamilton, who is engaged in animal nutrition research at the University of Illinois, has made some very pertinent statements regarding the function of phosphorus in the nutrition of farm animals. In an address before the Western Phosphate Conference, September, 1940, Doctor Hamilton said: "When animals subsist for long periods of time on forages which contain less than about 0.15 per cent (3 pounds per ton) phosphorus on the dry basis, aphosphorosis is a possibility, although there is usually no consistent and serious damage until the phosphorus content drops below 0.12 or 0.13 per cent (2.4 or 2.6 pounds per ton)." He explained that aphosphorosis is primarily a disease associated with phosphorus-deficient soils and consequently phosphorus-deficient forage crops.

These statements are quite definitely agreed on the serious possibilities of phosphorus deficiency in our soils and in our crops. The fact that a considerable portion of Illinois croplands have been found deficient in available phosphorus, along with the finding of a corresponding deficiency of phosphorus in forage crops grown on these lands, and the establishment of a limit value for desired amounts of phosphorus in these crops represent significant progress in research work on this particular problem.

Probably the largest areas of phosphorus-deficient soils are in southern Illinois and especially in the Ozark hill

TABLE 1.—PHOSPHORUS CONTENT IN POUNDS PER TON FOUND IN LEGUMES AND GRASSES FROM FOUR SOUTHERN ILLINOIS EXPERIMENT FIELDS

Soil Treatment	Ewing	Raleigh	Sparta		Elizabethtown			
	Alfalfa	Red clover	Lespedeza	Corn Stover	Timothy	Redtop	Bluegrass	Orchard grass
Phosphate added....	3.4	4.8	6.0	2.4	2.6	3.2	3.6	4.4
No phosphate.....	2.2	2.6	2.0	1.0	1.8	2.0	1.8	1.8

region of the extreme southern part of the State. In this hill region is located the Elizabethtown (Hardin County) experiment field from which some of the data in Table 1 were obtained.

The amounts of phosphorus found in timothy, redtop, bluegrass, and orchard grass (Table 1) from unphosphated land on the Elizabethtown field are far below the 3 pounds-a-ton limit given by Doctor Hamilton. Also from this field red clover and alfalfa hay on unphosphated land was found to be far below the 3 pounds-a-ton limit. Also in Table 1, alfalfa, red clover, lespedeza, and corn stover from unphosphate land on the Ewing, Raleigh, and Sparta fields had a phosphorus content far below the 3-pound limit. The experiment fields at Ewing, Raleigh, and Sparta are also located in southern Illinois and represent the more level to gently rolling farm lands.

As pointed out by Doctor Burlison, when forage crops are treated with liberal amounts of either rock phosphate or superphosphate the deficiency of phosphorus in the forage is largely overcome. This is apparent from the results in Table 1. When phosphate was added to the soil, the amounts of phosphorus in the forage were increased in most cases above the 3 pounds-a-ton limit. The exception to this were timothy hay and corn stover. Corn stover from the most fertile soils is seldom found to contain as high as 3 pounds of phosphorus per ton. The average is more nearly 2 pounds of phosphorus in a ton which includes stalks, leaves, sheaths, and husks. The amount of phosphorus in timothy hay may be brought up to and above 3 pounds a ton on these soils by the addition of phosphate alone, however, timothy responds to a more general improvement of the soil, that is legumes, residues, manure, and potash are usually needed in addition to the phosphate. In some cases lespedeza has been found to have requirements similar to timothy in this respect.

Phosphorus deficiencies in soils and crops are not confined to southern Illinois. Forage crops from experiment fields in both central and northern Illinois show some very decided deficiencies in phosphorus content. The Morrow plots in central Illinois produced red clover hay from untreated land with a phosphorus content of 2.2 pounds per ton of hay (1942). Red clover hay from limed land on the Joliet experiment field in northern Illinois had a phosphorus content of 1.8 pounds per ton of hay. Kentucky bluegrass from untreated soils on the Joliet field (1942) was found to contain 2.2 pounds of phosphorus per ton of hay. These values were considerably below the 3 pounds-a-ton limit. The use of phosphate in various forms on these central and northern Illinois soils has as a rule increased the phosphorus content of the forage crops to considerably above the 3 pounds-a-ton limit.

SOME CREDIT AGENCY ADJUSTMENTS FOR WARTIME NEEDS

H. S. WHALIN

The Federal Land Bank of St. Louis

When the Food-for-Freedom program was originally announced, Claude R. Wickard, Secretary of Agriculture, made the following statement, "The Nation is calling on farmers this year to turn out the greatest farm production in history. The people of America and the United Nations need more meat, milk, eggs, vegetables, fruits, and oil crops. We must have them for health and strength and critical military supplies. They are munitions of war. . .

"The services of banks and of Government farm credit institutions must be used as well as these other services. Adequate financing is vital to the success of the farmers' production program."[1]

This statement was made in connection with the food production program in 1942. Since that time the need has increased tremendously and it does not appear today that we can possibly produce as much in 1943 as is needed. Increased production demands the extension of additional credit by agencies financing farmers.

To the casual observer it may appear that most credit agencies have not made many changes in their operations in order to keep geared to the needs of our wartime economy. No doubt, some credit agencies have found it necessary or desirable to make more changes than others. There are some demands from the other branches of our wartime economy which have affected all credit agencies; for instance, the armed forces have taken many of the younger men from their ranks. War industries have been strong competitors for experienced personnel. Such demands have caused many changes in personnel resulting in loss of efficiency, at least temporarily, and in loss of the time used in training new employees. In many cases, these shifts in personnel have resulted in increasing the duties of the remaining employees in the organization.

Increased wages and prices together with heavy Government borrowings have resulted in greatly increased bank deposits and have enhanced the purchasing power and the debt paying ability of many individuals. With this condition prevailing, it becomes the patriotic duty of all credit agencies to do what they can to discourage inflationary trends without operating on a basis which would hamper the war effort.

It is not possible to cover all credit agencies in a review of this nature; consequently, I shall confine my remarks to a limited number of well known ones.

FARM CREDIT ADMINISTRATION

In the field of agricultural credit, the Farm Credit Administration holds an important position. The Federal Land Bank, the Production Credit Corporation, the Bank for Cooperatives, and the Intermediate Credit Bank are the four units which make up the Farm Credit Administration. As you may know, the Federal Land Bank makes long term loans to farmers on the security of first mortgages on farm lands; the Production Credit Corporation through the Production Credit Associations makes loans to farmers for production purposes, usually accepting chattel mortgage security; the Bank for Cooperatives finances farmers' cooperatives; and the Intermediate Credit Bank is a bank of discount. It discounts paper for the Production Credit Associations and the Bank for Cooperatives as well as for other agricultural lending agencies.

The Federal Land Banks hold a place of importance in the farm mortgage lending field. Together with the Federal Farm Mortgage Corporation, they have about 40 per cent of the farm mortgage loans outstanding in this country.

The Federal Land Bank of St. Louis, operating in Illinois, Missouri, and Ar-

[1]Bulletin: "How Banks can Assist in the Food-for-Freedom Program," by Agricultural Commission of the American Bankers Association. p. 5.

kansas, has adopted a balanced wartime program through which it and the National Farm Loan Associations are seeking to make their contribution to the farmers' war effort. This program is designed to emphasize the farmers' wartime responsibility and is divided into three sections: production, control of debts, and war bonds purchases. This program recognizes that farmers, like all other loyal citizens, are willing to do their full share in the Nation's war effort.

Production

All of us recognize that the farmers' most important wartime job is the maximum production of essential foods and fibers. The demand for food production on our American farms in 1943 is almost unlimited. The demand for certain farm products is acute and is increasing. We have not only the problem of providing food for ourselves and our armed forces, but have heavy demands coming from our Allies. Many conquered countries are looking to the American farmer ultimately to save them from starvation. Farmers did a commendable job in 1942 and they are planning to exceed this record this year in spite of shortages of machinery, supplies, and labor.

Control of Debt

Agriculture organized on a sound financial basis is a national asset. A sound financial program for the individual farm means much to the individual farm family. In periods of good farm income, farmers who are in debt should consider doing at least two things. First, anyone having a debt which cannot reasonably be expected to be repaid in full during these years of high farm income should put it on a long term amortized basis. He should also establish himself on a sound financial basis by setting up reserves. The farmer with a substantial mortgage debt needs to set up a reserve against that debt.

There are different methods which may be used to hedge against a mortgage debt. Term life insurance is an example. Under this plan, the borrower takes out a term life insurance policy at the time he obtains his mortgage loan. The amount and term of the policy are the same as for the mortgage. If he dies during the term of his policy, his mortgage is automatically paid by the insurance company.

The principle of hedging against a mortgage debt is so sound that the bank has incorporated it into its own program. Today any borrower from the Federal Land Bank can use his surplus funds to build to his credit a reserve in the bank to be drawn on for application on his loan as needed or as he sees fit. This reserve is called his "future payment fund." He receives an interest credit semi-annually on the money placed in this fund at the same interest rate he pays on his loan.

The other reserve which may be set up in periods of surplus income is one that will serve as a protection against unforeseen demands for cash. A reserve for such a purpose should be made up of the type of investments which meet two requirements. First, the investment should be of a liquid character under any and all circumstances; that is, the owner should be able to convert the investment into cash whenever he wants to do so. Second, it should also be the type of investment that can be converted into cash under any and all circumstances, at any time, at one hundred cents or more on the dollar.

War Bonds Purchases

Everyone should buy some War Bonds. The question for farmers is how much. On the basis of sound financial planning, the answer is easy:

1. Farmers who are still trying to get debts in shape should buy some war bonds; they will feel better for having done so.
2. Farmers who have reduced their indebtedness to a manageable basis under normal conditions should purchase the amount needed to fully establish adequate reserves.
3. Farmers who are out of debt should establish adequate reserves and buy as many more as their resources will permit.

It is not only good planning to have a reserve of War Bonds; it is also the patriotic privilege and the duty of every American citizen to buy them when his country is at war. William I. Myers, Consultant War Savings Staff United States Treasury says, "The financial welfare of farm people in the next two

decades depends to a great extent on the wise utilization of the higher farm incomes of the present war period. For the first time since the last World War, the incomes of farmers generally will provide a margin for reserves above necessary expenses. The overexpansion and speculation in agriculture between 1914 and 1920 resulted in suffering and loss in later years to thousands of farmers who expanded their business on credit at the inflated values of that period. The only effective way of avoiding the disastrous results of inflation and deflation is through using the increased incomes of this period to get debts in shape and to build financial reserves in War Bonds."[2]

The Federal Land Bank is continuing to make loans on the basis of "normal agricultural values." This loan policy is being followed by many of the other principal farm mortgage lending agencies in the country and it represents a sound means of preventing farm land booms.

Since the War started, the Federal Land Bank of St. Louis has liberalized its policy regarding the repayment of loans. Now, a borrower may pay any amount on his loan at any time, stopping accrual of interest on the amount paid on the day the payment is made, or he may retire his loan in full at any time without paying any penalty provided the funds are obtained from any source other than borrowing from a non-Governmental lending agency. This policy is in keeping with the purposes for which the Federal Land Bank System was originally organized; namely, to produce funds to finance farmers on terms suited to their needs with the lowest interest rates obtainable and on a basis which would enable them to retire the debt and finally own their farms clear of any encumbrance. During this period of above normal income, this policy has been beneficial to many farmers. The bank also allows its borrowers an interest credit on partial or full installment payments made in advance.

Many of the National Farm Loan Associations are assisting in the sale of War Bonds and stamps. In several instances, two or more of these associations have joined together as an operating unit using the same personnel, thereby releasing manpower for other work.

The Production Credit Corporation and the Production Credit Associations are taking an active part in financing agricultural production. The associations are ready and willing at all times to assist farmers with their financial problems. Their loans are all made for short terms and the turn-over is rapid and has stepped up since farm income has improved. The Production Credit Associations have given strong support to the war effort by standing ready to finance needed farm production at all times since the War started. Although the most important function of the Production Credit Associations is making loans to finance the production of Food-for-Freedom, they also have contributed much to the war effort in connection with the following programs:

1. Selling War Bonds and Stamps.
2. Encouraging the repair of farm machinery.
3. Discouraging unsound expansion.
4. Assisting the live-at-home program.
5. Encouraging payment of debts.
6. Helping farmers build financial reserves against future uncertainties.
7. Having representation on County USDA War Boards.

Commercial Banks

The American Bankers Association has actively supported the Food-for-Freedom program since it was originally announced and has encouraged all commercial banks to take an aggressive part in financing the production of food. Perhaps the largest reservoir of credit in this country is to be found in the deposits of individuals in commercial banks. Since large amounts of credit are needed at all times for efficient operations of farms, and extending credit is a normal function of banks, they have had the responsibility of handling much of the credit required by farmers in meeting their production goals.

The general distribution of commercial banks throughout the country makes it possible for them to provide prompt credit service to practically all farmers. Banks have accepted their responsibility for financing agricultural production and

[2] "A Wartime Program for United States Farmers," by William I. Myers; page 10. U. S. Government Printing Office.

have made a valuable contribution to the war effort in doing so. In doing this, they have increased their incomes by handling a larger volume of good agricultural loans. The banks have recognized the vital importance of increasing the production of food. They know that for many farmers, assurance of adequate credit was required before increased production could be undertaken.

Many banks have followed the recommendation of the American Bankers Association that each of them pick one man from among its officers and designate him as its farm contact officer. Where possible, a man trained in agriculture was to be placed in charge of the bank's farm credit department. All the bank's activities pertaining to agricultural defense financing are under the supervision of this man. He is charged with the responsibility of familiarizing himself with the Food-for-Freedom program, of keeping in close touch with the agricultural agencies operating in the territory, and of consulting with the bank's farm customers regarding their plans and programs. He is expected to spend considerable time contacting farmers on their farms in order to keep informed of their credit needs.

The Association also recommends that county-wide bankers' meetings be held to study the needs for agricultural financing, and to bring out ways banks can coperate with others in it. In addition to representatives from each bank in the county, representatives of the various federal and state agencies, farm organizations, and private agencies were to be asked to attend such meetings.

It is recommended that each bank weigh carefully every need for agricultural credit which comes to it, and if it cannot make the loan, steer it to some other commercial bank or other credit agency for consideration. Applications referred to other agencies are to be followed up to learn of their disposition. Applications that cannot be approved by any bank or credit agency are to be referred to the local War board with full information as to what would be required to justify the loan. When a loan is refused, the bank is expected to explain its reasons to the applicant as he may be able to correct the factors that caused the loan to be declined. It is also suggested that each bank explore every available agricultural resource in the county and take active part in seeing that it is developed to its fullest producing capacity.

It is not expected that banks will assume risks inconsistent with their obligations to their depositors. Better prices for farm products together with the price supports provided by the Secretary of Agriculture have improved the farmers' debt-paying ability. This means the banks can safely increase the amount of credit extended for agricultural production.

The banks are expected to take an active part in urging expansion by experienced, well equipped farmers on good farms who require only short-term credit to take care of increased expenses to get increased production and who do not need to make large capital investments or to become heavily indebted. It is felt that through personal contacts, loan policies, and publicity, the banks can discourage extravagant expenditures, the accumulation of unnecessarily large inventories, and the purchase of farm land at inflated prices, or the purchase of farm land with down payments that are too small. Loan values on farm land are to be kept at levels which are justified by long term prospects.

The banks have supported the "live-at-home" program, the machinery-repair program, and have encouraged economy in local government expenditures. They have taken an active part in the sales of War Bonds and stamps, not only in the over-the-counter transactions, but in organizing and assisting in the promotional sales work which has been carried on so successfully. Commercial banks also have contributed directly to the war effort by financing much of the Government's short-term credit needs, and by financing industry in connection with war production as well as other production essential to our national welfare.

Regional Agricultural Credit Corporation

The Regional Agricultural Credit Corporation seems to be the most misunderstood lending agency operating in the agricultural credit field today. The RACC was originally created under the Emergency Relief and Construction Act of 1932 to meet farmers' and stockmen's needs for short term credit.

Feeling the urgent need for maximum production on every American farm in 1943 and recognizing that there are always some farmers in every community who are unable to get financed properly for maximum production; also knowing that many farmers would be unwilling to take the financial risks inherent in expanding their operations for maximum production of war crops, Secretary of Agriculture, Claude R. Wickard announced early this year that $225,000,000 had been made available for lending to farmers at the county level for the production of essential war-time food and fiber. This additional source of credit for farmers was made available through the RACC. These loans may be made upon the approval of the chairman of the County USDA War Boards and the County RACC loan representatives.

In announcing this program, Secretary Wickard said, "The purpose of this program is to provide adequate financing to assure maximum production of needed commodities. These loans will be made only if it will enable the borrower to engage in or increase his production of essential agricultural commodities. For an applicant to qualify for a loan his farming operation should afford every reasonable assurance that the indebtedness will be liquidated. This program is not a substitute for other sources of credit, nor is it intended to compete with other lenders. Its purpose is to supplement such other sources of credit where needed. Each producer is urged to obtain his financial requirements, if possible, from other sources. Our farmers are faced with a tremendous production job in the 1943 Food-for-Freedom Program. We are doing everything in our power to help them meet the exceedingly high goals. By making available this new source of credit, we hope to enable every producer, large, medium or small, to produce to the limit without being hampered by inadequate financing."[1]

The RACC had not been active since 1934 and had no field force to handle this credit for farmers. An effort is being made to handle this credit for the RACC by using persons who are already engaged in work for some agency of the Department of Agriculture. The Farm Credit Administration was charged with the responsibility of the supervisory work of the program. F. W. Niemeyer, General Agent of the Farm Credit Administration, St. Louis, Missouri has been appointed as District Vice President of the RACC.

The RACC program is concerned primarily with increased production. It is not concerned with whether few or many loans are made. This is not a program for refinancing existing indebtedness. The mere transfer of a debt from one creditor to another will not aid production. Loans will not be made for the purchase of real estate or for the erection of extensive permanent improvements upon the farm.

Two types of loans are available through the RACC. One may be used for the production of general crops and all types of livestock and has been designated the "F-1 loan." The other type of loan is available for production of essential war crops and is called the "F-2 advance."

F-1 Loans

Loans under this program may be made to actual producers only. These include any farmer, stockman, or poultry producer, including any partnership or corporation engaged in agricultural or livestock production. Loans may also be made to any local group of farmers or stockmen formed for the purpose of acquiring larger items of machinery or equipment, sires, etc., for common use among the group, provided all members of the group join in executing the note, mortgage, etc.

Loans may be made to finance production, harvesting, and marketing of crops; purchasing, raising, breeding, fattening, and marketing of livestock; production and marketing of poultry, poultry products, and dairy products; purchase and repair of equipment essential to the farmer's production program; and for other purposes incident to the farming or livestock enterprise, including necessary labor and farm living expenses.

In general, the minimum collateral security required will be a first and paramount lien upon the crops to be produced, the chattels purchased, and the livestock or poultry in the production and care of which the proceeds of the loan are to be expended. Such other and additional collateral as the County War Board or

[1]Press release.

the Corporation's loan representative may deem necessary or advisable to afford adequate protection for the debt may be accepted.

All notes are to have a maturity date of one year or less and will draw interest at the rate of 5 per cent per annum payable at maturity. The maturity date should coincide as nearly as practicable with the usual time for marketing the crops or livestock from which liquidation is expected.

F-2 Advances

In cases where the County War Board finds that a farmer has capacity to produce essential crops and when such production can be related definitely to the use of the proceeds of the advance, the RACC through its local representative may advance to such farmers the amount determined by the War Board to be necessary to finance such production. Such advances may be made on the following terms, which shall be stated in the note or notes evidencing them: The borrower shall undertake production of a specified quantity of essential crops and shall be personally liable for the full amount of the advance; except that, if the County War Board certifies that

1. The borrower has used the amount advanced for producing the crops for the production of which the advance was made;
2. The borrower in good faith has diligently applied principles of good husbandry to the production of such crops;
3. The borrower has applied an amount equal to all proceeds of such crops to the repayment of the advance; and
4. Such amount has been insufficient to repay the advance in full,

then the RACC will not look to other assets of the borrower for the repayment of that part of the advance which exceeds such proceeds but will cancel the borrower's obligation for the balance of the advance.

The following crops have been designated by the Food Production Administration as "essential war crops" the production of which may be financed under this program:

Soybeans for beans
Flax for seed or fiber
Peanuts to be harvested and picked
Irish potatoes where farm goal is 3 acres or more
Sweet potatoes on farms with goals determined
American Egyptian cotton
Hemp for seed or fiber
Dry beans
Dry peas (excluding wrinkled varieties)
Castor beans
Tomatoes, snap beans, lima beans, peas, and carrots for processing or sale fresh
Cabbage, sweet corn, and table beets for processing only.

These advances shall be made only to farmers who are actual producers. The advances may be made to finance the actual current cash cost of producing and harvesting designated essential war crops and delivering such crops for sale or for processing. In all cases advances made must be secured by a first and paramount lien upon the specific crop to be produced. All notes shall be drawn with a maturity of one year or less and shall draw interest at the rate of 5 per cent per annum.

In making both F-1 loans and F-2 advances, the County USDA War Boards have definite responsibilities. It is their duty to see that the lack of credit does not stand in the way of maximum farm production in their counties in 1943. It is also intended that they handle the RACC loan so that it will not be in direct competition with credit available from other local short-term lenders. In order to assit the RACC loan representatives and the County USDA War Boards in determining when to make RACC credit available to farmers, the following yardstick, or guide, has been worked out for their use in considering applications:

1. Is the applicant eligible?
2. Will the loan maintain or increase production?
3. Does the application show the funds will be used for proper purposes?
4. Is there a probability of successful operation and repayment?
5. Can and will the applicant give satisfactory security?
6. Can and will the applicant produce as much if RACC funds are not available?

If answers to the first five questions are yes and to the sixth one no, then the loan should be made.

SUMMARY

The lending policy of the Federal Land Banks, based on normal values, acts as a deterrent to inflated land values. This policy is much the same as that expressed for Commercial banks in handling real estate loans. The adjustments made by the Federal Land Bank since the war started all seem to be of the nature which are of direct benefit to farmer borrowers and indicate concern for the future. No doubt, the farmer who establishes adequate reserves now will be able to weather bad times better when they come.

The Production Credit Associations and the Commercial banks are doing a commendable job of handling the financing of production for farmers. Both organizations are making every effort to assist in the war effort and have not limited their activities in connection with aiding the prosecution of the War to lending money where credit would be beneficial to producers. Financing agriculture represents only a portion of the credit furnished by Commercial banks to assist the prosecution of the war.

The funds made available through the Regional Agricultural Credit Corporation make it possible for the County USDA War Boards to see that every farmer has the credit needed for maximum production on his farm. This credit is to be used as a supplement to other sources of production credit which are available.

It does not appear that any of these credit agencies have permitted the difficulties resulting from the wartime economy to noticeably hamper the service they are rendering the public.

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PAPERS IN ANTHROPOLOGY

EXTRACT FROM THE REPORT OF THE CHAIRMAN

The program included eleven papers, ten of which were presented at the Jacksonville meeting. Two additional papers were added on the day of the meeting. Authors and titles of papers not herein published are as follows:

BURFORD, C. C., Champaign, Illinois, *Exit—the Red man; enter—the White man.*

COLE, FAY-COOPER, University of Chicago.

GRIFFIN, JOHN, University of Chicago, *Typology in archaeology.*

LINK, G. M., Michael, Illinois, *The prehistoric Indian in Calhoun County.*

MCGREGOR, J. C., Springfield, *Aims and methods of archaeology.*

SPOONER, H. L., Peoria, *Who were the prehistoric peoples of Illinois?*

TITTERINGTON, P. F., A film and slides on *Research work in Calhoun County, Illinois.*

The attendance at the meeting was 65.

DONALD E. WRAY, 604 Caroline Street, Peoria, was elected chairman for the year 1943-1944.

(Signed) BEN NUSSBAUM, *Chairman*

ARROWSMITH BATTLEFIELD

WILLIAM B. BRIGHAM

Bloomington, Illinois

Soon after their first contact with the French in Wisconsin, the Fox Indians developed a feeling of distrust and suspicion that later broke out in hostilities. The skirmishes interfered greatly with trade and settlement over a large portion of New France.

After many years of unpleasant relations with this tribe, the French authorities secured the assistance of other Indian tribes to aid in the destruction of the Foxes. A battle to that end, fought in 1730, lasted twenty-three days. It is recorded in history, but its location is not definite. Two authorities have selected sites near Starved Rock. Another has placed a marker for it on a hill near Plano. Reports, later uncovered, describe it as southeast of Starved Rock, about 150 miles south of Lake Michigan, and on a vast prairie between the Illinois and Wabash rivers. The Arrowsmith site in eastern McLean County fits well into this description.

When the white settlers came to the vicinity of the battlefield, they noticed numerous circular pits on the hill. The zigzag rifle pits to the northeast and southeast have long since been obliterated by cultivation. The ridge of yellow clay approaching the hill from the northeast (DeVilliers' attempt to undermine the fort) is no longer visible.

However, the archaeologist would be better satisfied after inspecting the various remains. Careful excavations of this site have revealed much of interest. By digging to the undisturbed soil at a depth of about thirty inches many interesting relics have been found. These include traders' axes, patina-coated bullets, broken bones, a razor blade, and other metal fragments. Studies of the finds show each piece to be readily associated with the period of this battle.

Thorne Deuel, after looking the situation over carefully, expressed much satisfaction. With his assistance a number of relics were sent to Arthur Woodward, Director of Anthropology at Los Angeles County Museum. After examining them, Mr. Woodward stated that these were implements in common use about 1730 and that many such axes were made in Utrecht, Holland.

Mr. Deuel also asked the opinion of George I. Quimley, Jr., of the Department of Geology at Louisiana University. He placed the period of the pieces submitted to him at 1700 to 1760.

One of the bullets was found in the heart of a large oak log when it was being sawed. It is regrettable that no one thought to count the rings of growth in the tree. Our friend, John McGregor, could have actually checked the calendar had he been there.

An airplane photograph of the Arrowsmith site shows the bend in the stream and the direction in which it runs. In those respects it is almost a complete duplication of the map made by DeLery, French army engineer at Quebec, upon receipt of the report of the battle in October 1730.

While the historical records are rather conclusive, the traces that linger have helped to tell the story of this conflict. Those of us who have examined all data pertaining to the Arrowsmith Battlefield now feel it is definitely identified as the scene of the battle that sealed the fate of the Fox nation.

Relics from Arrowsmith Battlefield (three-eighths size).

First row: Section of bullet-lodged gun barrel fashioned into scraper, gun flints.

Second row: Section of gun barrel, war points for arrows.

Third row: Section of gun barrel, three patina-coated musket balls.

Fourth row: Blade of hunting knife, piece of sheet copper used as a patch.

Fifth row: Razor blade bearing a French name (Pierre Meman) the maker, section of gun barrel.

Sixth row: Two traders axes, piece of bone broken to obtain marrow.

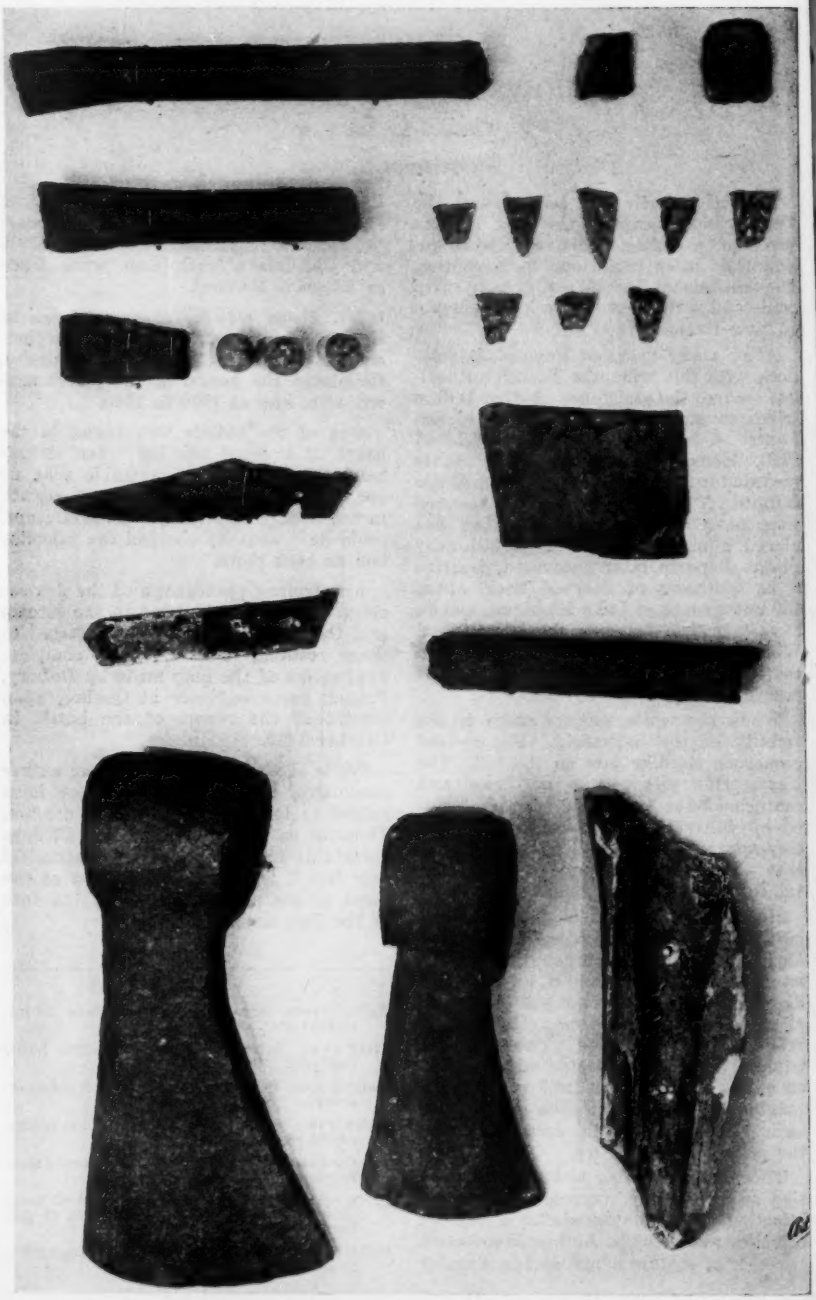

Fig. 1.—Relics from the Arrowsmith Battlefield.

AN ILLINOIS CORNER-TANG

C. W. HUDELSON

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One of the most unusual and highly prized Indian artifacts is the corner-tang or, in everyday words, a special kind of knife blade. This is undoubtedly a prehistoric implement which was developed, not by an agricultural race, but by tribes who lived for the most part by hunting.

In considering the origin of the corner-tang knife blades it may be assumed that these artifacts did not spring into existence with the suddenness of a new chance discovery, but, like most all man-made implements, were gradually developed and perfected throughout long periods of time from some basic tool.

Mr. W. K. Moorehead has suggested that the corner-tang must have been used for cutting soft meat, like that of fish, and this suggestion undoubtedly constitutes the source of the term "fish knife," which is one of the common names applied to these pieces.

It is a well established fact that the American aborigines used this tool as a two-edged cutting knife and it is therefore reasonable to assume that the corner-tang knife represents an evolution of the spearhead type of knife. Many corner-tangs have a curved edge which would make an excellent knife for skinning.

Corner-tangs were made from flint, the predominate shape is triangular, and the distinctive structural feature is the tang. The tang, or projecting prong, is the part to which the handle was hafted or fastened, and is located at any one of a number of places, such as the corner, base, back, mid-back, etc.

The diagonal corner-tang knife should probably be regarded as the common or standard type for corner-tang tools, since fifty per cent of all reported specimens are of this type (Fig. 1.). It is generally composed of a triangular blade with the tang located on one of the corners at the base, and with the main axis of the tang touching the long axis of the blade at an angle of about forty-five degrees. The tang located at this angle would have the effect of raising the free end of the attached handle considerably above the level of the cutting edge and this would make the knife more suitable and convenient for skinning than could be the case in the hafted base-tang knife.

According to distribution studies made by Professor J. T. Patterson of the University of Texas at Austin published in 1936 and 1937, corner-tang pieces were developed and used in central Texas. However, they have been found in the group of states located between the Mississippi River and the Rocky Mountains extending from Texas to Montana, and also in Illinois and Mississippi. By far the greatest number of these artifacts have been found in central Texas. The main line of distribution follows for the most part the course of the Balcones Fault Line. The flint exposures throughout this region furnished an abundant supply of raw material from which to

Fig. 1.—A diagonal corner-tang, actual size.

make these unusual stone tools. The many large springs along the fault line furnished the water necessary for Indian habitations, and large herds of game animals roamed over this territory even after the first white pioneer settlers arrived. Once these corner-tangs were developed they must have been used by succeeding generations of aborigines, even down into the times of the pioneer whites. Therefore it is not surprising to find artifacts in this region which reflect the huntsman's type of life.

It is interesting to note that B. W. Stephens of Quincy, Illinois, reported to Professor Patterson a single specimen in his own collection from Calhoun County. If others have been found in Illinois, they have not been recorded so far as the writer knows.

The writer found his specimen in a cornfield due north and about two hundred yards from the Dickson Mound site on Sunday, September 29, 1940. Dr. Don Dickson made this comment at the time, "A corner-tang is one of the rarest Indian artifacts to be found in Illinois."

The occasional finding of one of these coveted and unusual pieces furnishes a thrill not to be duplicated in any other hobby. The long hours involved, the countless miles covered, and the great amount of energy expended in its search are quickly forgotten when such a prize lies safely in one's hand or pocket.

PREHISTORIC INDIAN MOUNDS OF CENTRAL EASTERN ILLINOIS

FRANCIS A. LOWRY

Champaign, Illinois

This report records findings made in a survey of the evidence of man's previous occupancy of central eastern Illinois. The survey was made during 1939, 1941, and 1942.

Piatt, Champaign, Vermilion, Douglas, and Coles counties have a combined area of 3,357 square miles, all are occupied in part by glacial moraines, and all have many streams. Large streams in the general area are the Wabash to the east, the Sangamon to the west, the Kaskaskia, the Embarrass, Salt Fork, Middle Fork, and Little Vermilion—all streams that would have supplied clear water, transportation, and food. These counties comprised part of the Illinois prairies, surrounded by the heavy timber that naturally followed the water courses. Even after the white men came, the prairies were well stocked with game, and must have offered similar attractive living conditions to primitive peoples.

A survey of prehistoric Indian mounds in the area was started in 1939. These five counties still contain more than 160 man-made mounds and hundreds of camp sites. Many house rings still reveal the sites of permanent houses, and many of the camp sites still contain artifacts—I have picked up as many as 30 arrowheads from one site. Many stones that show intense heating were probably used in the cooking of food. Pottery of both grit- and shell-temper is to be found on some of the larger sites that were occupied longer. Polished ornaments, grooved axes, celts, knives, and drills all give us some knowledge of how these early people must have lived.

VERMILION COUNTY

Vermilion County was occupied by Indians when the first white settlers came. Their Piankishaw settlement on the present site of Danville was larger than the present city. But evidence of still more ancient occupation is found in the mounds. On the land now owned by J. S. Seyfert, Blount Township, on the Middle Fork, stand two mounds on the east side of the river. On a high bluff overlooking

a wide expanse of lowland is one of the largest as well as one of the smallest of any of the mounds examined. The largest is 70 feet long, 50 feet wide, and fully 10 feet high. Just 60 yards to the north is the smallest, not more than 12 feet across and 2 feet high. This land has never been cultivated, and the source of the material used in building the mounds is evident in nearby depressions. Neither mound has been explored, and on the larger stands an oak tree some 18 inches in diameter. Not more than half a mile to the southeast on land owned by Harry Henthorn of Veedersburg, Indiana, on the east side of the same river, rises a rather high ridge of gravel. Workmen removing gravel about 40 yards up the slope uncovered 16 pits, 3 feet across and 4-5 feet deep, sunk in four rows, four pits to the row. Each contained a flexed skeleton in a sitting position. The only artifacts found were flint arrowheads in an oval pottery bowl, discovered by accidentally breaking the bowl. This information was given me by Mr. Henthorn shortly after the discovery. This rise in land is the shore of what was once quite a large lake. Three more mounds lie just across the river to the west but as yet they have not been examined. South and east on the bluff of this same lake bed are many mounds all of which were explored many years ago. Many artifacts of beautiful workmanship have been uncovered in this district in late years. In all, Vermilion County has more than 40 mounds which are still in good repair.

Champaign County

The land in Champaign County is more level but there is still evidence that man was here many years ago. In sec. 36, Newcomb Township, near a bend of Sangamon River, are five mounds, some say more, in what is known as Brownfield Woods. These were all excavated some years ago and there is little information as to the contents. Just over the township line in Mahomet Township, sec. 1, are three more mounds located on a small creek which flows into the Sangamon. They are locally known as the Nancey Mounds. Several burials were uncovered in taking gravel, but they were not recorded. The central mound, located on a prominent point of ground almost surrounded by this small stream, was excavated by the Champaign County Archaeology Society in May and June of 1939. This mound, oval in shape, is approximately 36 feet wide and 40 feet long with a depth of 5 feet to subsoil. The excavation is interesting because it disclosed three types of burials—flexed, cremated, and extended—and yielded notched, stemmed, and triangular arrowpoints, polished slate, and an extensive fire-pit. Six skeletons were found at different levels. There are many large camp sites within a short distance of these mounds, and other mounds are to be found within a radius of a few miles. Additional camp sites are to be found along the streams throughout the county. There was another mound at the extreme south, just north of the county line on Fourmile Creek, but it was dug and has been cultivated for many years and is almost level. It is reported that a large flat stone covered this burial. Champaign County has 25 mounds that remain visible.

Piatt County

In Piatt County along Sangamon River are 37 mounds, located singly, in twos, and in groups. The Clark Mounds north of Monticello number 21, although at least one more has been destroyed. These have been pitted, but they are so large that little damage has been done. On the Allerton estate near what is known as Hog Shut bridge is another group on the east side of the river; it contains nine oval mounds and one elongated mound some 15 feet wide by 60 feet long. Blue Ridge Township has two, and near Atwood a group has been reported but not yet checked.

Douglas County

Localities along the Kaskaskia and the Embarrass and in Douglas County reveal 42 mounds, literally hundreds of camp sites, a group of house rings, and Indian legends of buried gold. South of Parkville in Douglas County, across Fourmile Creek and within 700 yards of the mound site in Champaign County, is an elongated oval mound some 50 feet long, 25 feet wide, and about 4 feet high. This mound has been pitted. The owner still has hopes of riches so we neither dug

nor measured. On the Miller farm south and west is a group of eight mounds on the west side of Kaskaskia River. One was trenched throughout the length and width but showed nothing but small pieces of charcoal, pot sherds, and one small notched base arrow. No work was done on the remaining mounds.

North of Ficklin at the Kaskaskia school are a number of house rings, and many artifacts have been found in this location. Still farther north is a rather large horseshoe-shaped mound. Several mounds are reported near Chesterville. Near Villa Grove High School, on the banks of the Embarrass, are three large mounds. One has been partly dug, but the other two are still as the builders left them, for the land is in pasture and to all knowledge has never been plowed. Three miles south of Villa Grove, as the river crosses the highway, to the south and east lies a group of four mounds, two of which show pitting but not much damage.

At Camargo to the south are the mounds known as the Camargo group. They are five in number and this group was chosen for excavation by the Champaign County Society. The mounds are laid out almost northeast by southwest. Mound number one lies near the edge of the bluff and the river and was opened in the fall of 1939 and spring of 1940. It measures 58 feet east-west and 43 feet north-south with a depth of 38 inches to subsoil. One complete skeleton, two skulls, and three bundle burials were found. With the extended skeleton at a depth of 37 inches was a platform pipe of very soft material and a sharply pointed four-sided copper awl 6½ inches long. Slightly above the two skulls at depths of 18 and 22 inches was found the two halves of a slate gorgett which matched perfectly. It contained four drillings on one half and three on the other. The bundle burials consisted of the large bones of the arms and legs. All were in quite solid condition and outlines could be followed easily. Other artifacts were boiling stones, pot sherds, and three small arrows. Two areas show where extensive fires had been used, and charcoal was found in small quantities throughout the excavation.

Mound number two, south and west of mound one, was excavated in 1938. It measured 65 feet east-west, 45 feet north-south. Ten feet from the north edge the first of five skeletons was found. They lay side by side within 10 feet, and two bundle burials took another four feet. The rest of the mound was unoccupied. The unusual shape of the mound suggests that the original mound and burials were made and that the rest was added later. With the skeletons were two copper axes, a large stone, elbow pipe, and a copper spear of ceremonial appearance.

Mound number three had been pitted by someone over-anxious while the society was absent, and all that could be determined was a layer of three or four inches of charcoal above the burial place. A few particles of bones and a small black flint notched arrow was found in the dirt that had been removed.

Mound number four was trenched. At a depth of 18 inches lay a layer of charcoal below which we encountered one of the most unusual of all finds—7 inches of almost solid ash, containing human bones that were too soft to excavate so that only diameters and lengths could be measured. The deposit extended 11 feet north and south and continued beyond the length of the trench, which was 15 feet east-west. No artifacts were found.

Mound number five of this group showed no remains whatever.

Several more mounds are to be found on the Embarrass to the south.

Coles County

In Coles County nineteen mounds have been located and probably many more will be found when work can be resumed.

In conclusion of this report, the writer has reached the belief that the majority of facts found in this survey points to the existence of two ancient cultures, seperated by a lapse of time, in central eastern Illinois.

A METHOD FOR DETERMINING MOUNDS AND MOUND GROUPS IN THE WISCONSIN GLACIAL AREA OF CENTRAL EASTERN ILLINOIS

JOHN BRYAN RUYLE

Champaign, Illinois

INTRODUCTION

In the spring of 1943, the writer, after five years of field work, completed an archaeological survey of Douglas County, Illinois, located 150 miles south of Chicago, Illinois, and 27 miles west of the Illinois-Indiana state-line. The archaeology of Douglas County is the archaeology of its main streams and tributaries, as in all other counties.

The investigation was made chiefly along the Embarrass and Kaskaskia rivers. Both rivers originate on the southern slope of a branch of the Champaign morainic system. The Embarrass begins directly south of the grounds of the University of Illinois and flows through the eastern portion of Douglas County. The Kaskaskia begins five miles west and somewhat north of the city of Champaign, and flows directly south through the western part of Douglas County. These streams closely resemble each other today. Their headwaters are immediately adjacent. Both have equal lengths of approximately 25 miles through the county. The widths and depth of the streams are nearly constant, and the forest belts along their margins are of equal widths.

Forty mounds and several large camp and village sites were found on Embarrass River and no mounds and only one village site on the Kaskaskia. Flint chips picked up on the latter site put it in a subordinate rôle for they show that it was probably used by the large bands that occupied more permanent camps on the Embarrass. The same type of flint was found at both places and the same method of chipping was employed. All of the large camp sites were located on the north and east banks of the river.

A study of a morainic map, distributed by the Illinois State Geological Survey, shows that in Douglas County Kaskaskia River lies several miles to the west of any morainic system, while Embarrass River, in the northern part of Douglas County, crosses the Savoy ridge, a branch of the Champaign morainic system. This study of the morainic map leads the writer to believe that all migrations of the prehistoric Indians into the Prairie Province were by way of moraines. They were the boulevards of a thousand years ago across the wet marshy prairies, corresponding to the elevated transcontinental highways of tomorrow across the United States.

The writer believes that the Indians camped on the east banks of the rivers not to be safe from prairie fires or because they were afforded more shelter in winter, but because there they found heaviest growths of timber and consequently the largest concentrations of game and wood. The writer has searched the literature regarding the opinions set forth herein, and has found that no one has ever before expressed similar theories. These statements are advanced as an hypothesis. To state that they hold true for all of the 50 counties in the Prairie Province, or Early Wisconsin glacial area may be erroneous, for that would necessitate counting all the mounds in that area, many of which were long ago obliterated by the plow, as well as study of all camp and village sites. Likewise it might not hold true along large waterways, notably Illinois River, even though it may apply to the counties of Champaign, Vermilion, Piatt, Douglas, McLean, Livingston, and Coles, insofar as a systematic survey can show.

MORAINES AS PATHWAYS OF MIGRATIONS

The moraines that the author believes were pathways of Indian migration were deposited by the Wisconsin glacier, which represents the fourth glacial stage of the Pleistocene or last period of geologic time. This glacier advanced southward into Illinois as far as Paris, Charles-

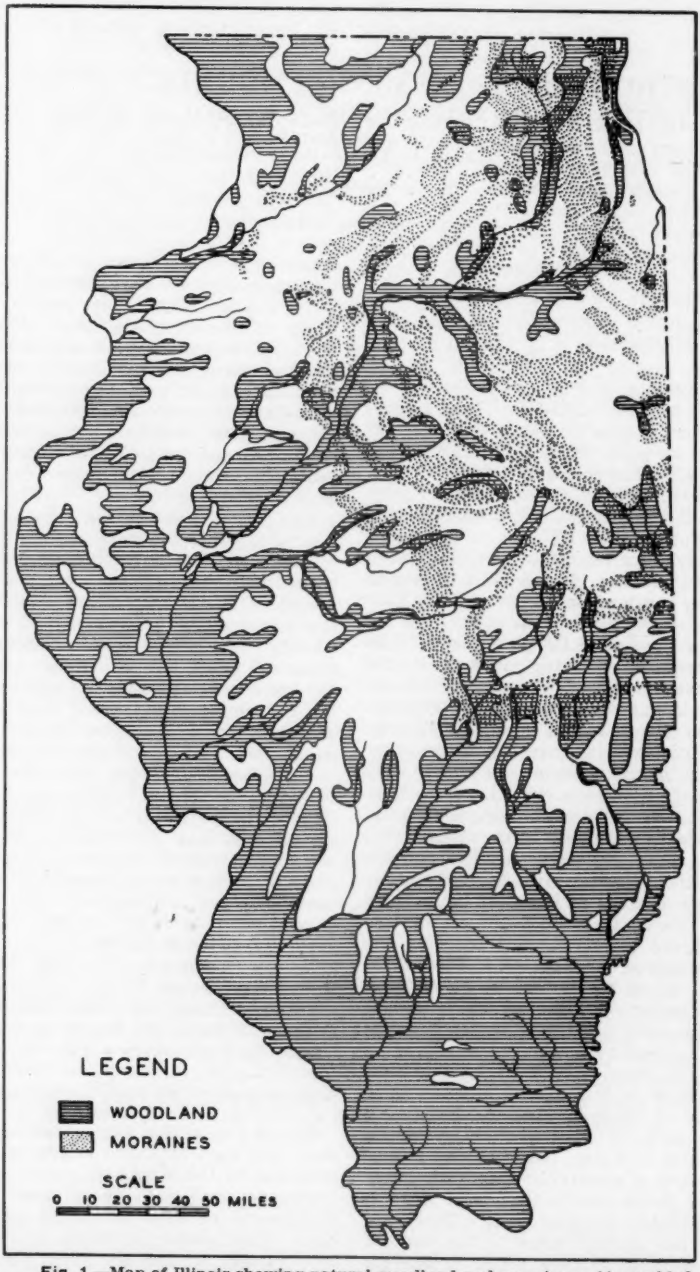

Fig. 1.—Map of Illinois showing natural woodland and moraines. (Assembled from data compiled by State Natural History and State Geological Surveys.)

ton, and Shelbyville. When the glacier reached this position, the melting of the ice equaled its advance, so its margin was relatively stationary for a considerable time and along it accumulated a ridge of glacial drift or ice-borne debris. This ridge is known as the Shelbyville moraine. Subsequently the ice-front receded and readvanced to positions successively behind the Shelbyville moraine, and there built the Champaign, Bloomington, and other moraines.

After the glacial ice disappeared there was a conflict between the long-stem bluegrass which thrives east of the 100th Meridian, and the deciduous trees to the south. The grass won, for the rainfall was insufficient to support forest growth. Also, the long-stem bluegrass completed its cycle sooner and shaded out the forest seedlings, and the poorly-drained land was not conducive to the growth of the seedlings. The Shelbyville and Bloomington morainic systems extended through this area, 150 feet high, like planks across a muddy road. As they were better drained than the flat terrain surrounding them, the east and north sides were the first to become wooded. The prevailing winds in this area are from the west, so the corresponding banks of the streams were the first to receive tree seeds. The afternoon sun, shining on the east and north banks produced higher temperatures for growing the vegetation than did the morning sun, shining on the west and south banks.

The moraines were first covered by trees at their edges, by willows in the stagnant pools, then next the sycamores, followed by oak-hickory. It is reasonable to assume that primitive man used these prehistoric highways, for the Prairie Province was an ocean of grass with a few islands of timber, and only the streams had extensive timber belts. In these islands of timber, and along the streams, lived the animals that would feed and clothe the Indians. From the tops of the moraines the Indians could wage offensive and defensive warfare; so the writer believes that the migration from the east, north, and west was via the moraine systems. There is possibly another reason that the prehistoric Indian buried his dead on the east bank of streams and that is that the east bank is more often steeper and higher.

From the south I believe that entrance was gained into the Prairie Province by way of the Vermilion, Little Wabash and Embarrass rivers. Gurdon Hubbard, when trading at Danville, floated a boat load of produce to New Orleans, and in the early days on Embarrass River, near Charleston, there was a large flat-boat building concern, so to cross to the region in the light canoes of the Indians would not have been difficult. A glance at the map shows the most direct route via water to be by the Embarrass into the Prairie Province from the south. By way of the Kaskaskia it would have been necessary to battle the up-stream current of the Mississippi for miles to reach the confluence of the Mississippi and Kaskaskia.

Preponderance of Mounds and Campsites on the East and North Banks of Streams

I do not believe, as many archaeologists do, that the Indians camped and lived on the east banks of streams as a protection against forest fires. It is true that the prevailing winds are from the west, but forest fires do not occur in winter and spring. In summer and fall when the danger is great, the streams are low and can be easily waded. Also it has been set forth that the Indians wanted the protection of the trees against winter winds. A glance at a soil map will show that the timber belts of streams in the area of early Wisconsin glaciation are only one-half as wide on the west side as on the east side of the river. Research has shown that all hunting parties moved into regions where timber was thickest and where the largest concentrations of game animals are to be found. In the area of Wisconsin glaciation this would be on the east and north sides of the streams.

Another feature that might have influenced their choice was the presence of Tabanid flies. County histories and newspaper items regarding early settlers have shown that the horseflies and other species of the Tabanid group were so vicious that travel could be undertaken only at certain hours. They would attack oxen and horses; causing them to become uncontrollable, endangering the life of the rider or driver. A newspaper item regarding an old settler relates that he

would often return from a day's work in the field, with his shirt drenched with blood as a result of the bites of vicious flies. The Tabanid flies bred in the stagnant pools of the poorly drained prairies. With winds blowing from the west, these flies would be blown into the timber lines along the west banks.

To one who thinks that the above facts are fanciful, I would like to call your attention to the fact that all but one of the county seats in the area of Wisconsin glaciation area are located on or near moraines. The one exception is in Douglas County where the first county seat, Camargo, was located on a branch of the Champaign moraine. All of the early towns were located on or close to moraines. The pioneer dead were interred in drumlins, kames, or the moraine itself. The early schools were also so located.

ACKNOWLEDGMENTS

The writer is indebted to innumerable individuals for their help and advice: Dr. Arthur G. Vestal, plant ecologist, University of Illinois, for his theory on plant and forest distribution and the reason for the north and east banks being more heavily wooded; Dr. Victor E. Shelford, animal ecologist, University of Illinois, for animal distribution; Don Carroll, Illinois State Geological Survey, for his pertinent comments on the geology of the region; Dr. Walter V. Balduf, Entomology Department, University of Illinois, for his notes on the life history of the Tabanid flies.

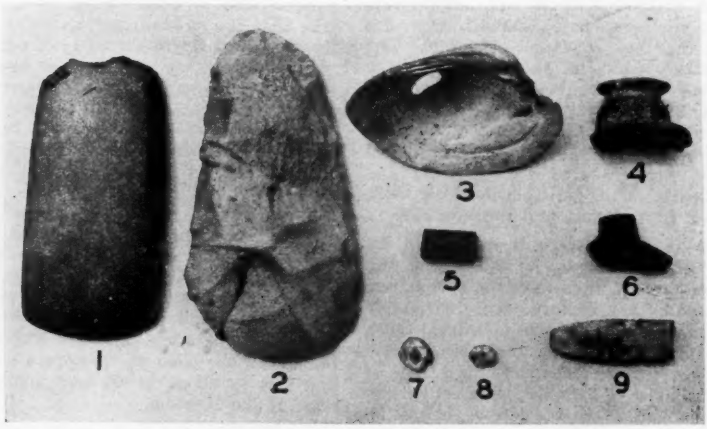

Fig. 1.—CULTURAL OBJECTS FROM CLEAR LAKE VILLAGE.
(Photograph by William Holling.)

1. Polished hematite 6 in. adz, or blade
2. Flint spade, with blade edge polished from use
3. Shell spoon, with unevenly shaped, oddly placed hole
4. Broken platform pipe made from fossil
5. Section of a stone bar with ¾ groove. (Not yet identified)
6. Broken platform pipe made of clay
7. Disk-shaped shell bead, perforated through the larger dimension
8. Shell bead made from *Anculosa praerosa*
9. End portion of a stone bar, having a partial groove. (Not yet identified)

SOME DATA ON CLEAR LAKE VILLAGE CULTURAL OBJECTS

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Data on the incompletely excavated Clear Lake village[1] given in this paper concern material excavated by Mr. and Mrs. George Schoenbeck and Anson Simpson, members of the Peoria Academy of Science. It comprises a brief account of recently excavated objects of particular interest and a list of the shells, including the mollusks as identified by Dr. Henry van der Schalie[2] and the gastropods, identified by Mr. Calvin Goodrich.[3]

The abundant pottery has included two out-of-the-ordinary items, not yet identified, a rim with cameo decoration and a sherd with two opposite finished edges, which might be described as a 2-inch portion of a band 2½ inches wide.

Other objects of interest were two platform pipes, one made from a fossil and one from clay; a flint spade similar to those of southern Illinois, from the lowest habitation depth; a flat 6-inch polished hematite adz, or blade, from the upper depth; portions of two stone items, not yet identified, described here as bars with transverse grooves. Two shell objects were a disk-shaped bead with crosswise perforation (such as might account for the previously reported shells with variously located cut-out circular portions) and a shell carved into a human face in profile. Occasional shell spoons, made from *Lampsilis ventricosa*, each show an unevenly shaped hole in the center.

Not yet explained are two sharply defined curved compact layers, each composed of charcoal, sooty rocks, and blackened sand, lying one above the other with a layer of other sand between. The relative position, the outline and the condition of the two layers suggest to the writer layers in the rounded bottom of a pit approximately 8 x 6 feet in size, possibly an unopened roasting pit. A concentration of an unusual number of animal bones, comprising bison, deer, dog?, turtle, beaver, and human bones, lay near by.

The mollusk series, stated to be that of a large river with the exception of one creek species, *Mycromya iris*, comprised 24 species, including *Elliptio dilatatus, E. crassidens, Pleurobema cordatum coccineum, P. cordatum solidum, P. cordatum catillus, Fusconaias undata, F. flava, Amblema peruviana, Megalonaias gigantea, Cyclonaias tuberculata, Plethobasus cyphyus, Quadrula pustulosa, Q. nodulata, Micromya iris, Ligumia recta latissima, Plagiola lineolata, Actinonaias carinata, Proptera alata, Lampsilis ventricosa, L. siliquoidea, L. siliquoidea rosacea, Anodonta grandis, Leptodea fragilis* (probably), *Lasmigona complanata.*

The presence of a number of *Elliptio crassidens*, a species stated to be more common farther south although known in Illinois River, more or less as a straggler, and the scarcity of representatives of the *Anodontinae* were noted.

The gastropods were identified as 13 species, including *Mesodon pennsylvanicus, Mesodon thyroidus, Anguispira alternata, Anguispira kochi, Allogona profunda, Pleurosera acuta, Physa gyrina, Campeloma integra, Lymnaea palustris, Lioplax subcarinatus, Helisoma trivolvis, Goniobasis livescens,* and *Anculosa praerosa.* The nearest known habitat of *Anculosa praerosa*, a specimen which had been made into a bead, was given as Grand Chains, Wabash River, Posey County, Indiana.

[1]The Clear Lake Village site in Tazewell and Mason counties was originally investigated by the University of Chicago and described by Fay-Cooper Cole and Thorne Deuel in "Rediscovering Illinois," University of Chicago publication, 1937.

[2]Dr. Henry van der Schalie, Museum of Zoology, University of Michigan.

[3]Mr. Calvin Goodrich, Museum of Zoology, University of Michigan.

THE ILLINOIS CONFEDERACY AND MIDDLE MISSISSIPPIAN CULTURE IN ILLINOIS

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INTRODUCTION

In the past decade the archaeology of the Middlewest and the whole eastern United States has been clarified with surprising speed, and in place of the previous jumble of unrelated cultural groups we now have a series of culture stages which can be arranged in chronological order. This progress has been the result of the careful excavations carried on throughout the eastern part of the country and has been further developed by the application of the Midwest taxonomic scheme for classifying related cultures. John Bennett described the archaeology of the Midwest at our meeting last year, but I will again briefly summarize the cultural sequences so that they will be clear in our minds.

The major published work for this area is Cole and Deuel's *Rediscovering Illinois*. In this book, based on Fulton County material, the authors distinguish five cultures. These are, in sequence, the Black Sand, Red Ochre, Central Basin, and Hopewell, all of these being Woodland; followed by the Spoon River focus of Middle Mississippian. Another Woodland culture, the Maples Mills or Tampico, shows Mississippian influence and may have been contemporaneous with Spoon River.

In an article in the *American Anthropologist*, Ford and Willey have made a synthesis of all the material from the Mississippi Valley.[1] They distinguish five major stages of cultural development; the archaic, Burial Mound I and II, and Temple Mound I and II. The Fulton County material corresponds with the Ford and Willey scheme in this way; Red Ochre is Burial Mound I, Hopewell is Burial Mound II; Maples Mills is transitional between Burial Mound II and Temple Mound I; the Old Village at Cahokia is Temple Mound I; Spoon River is Temple Mound II as is the Trappist aspect at Cahokia. In connection with the Ford and Willey scheme it must be borne in mind that they assume that the Middle Mississippian cultures (Temple Mound I and II) originated in the lower Mississippi valley and spread northward, so that the same culture period is older in the south than in the north.

The facts just outlined are an elaboration and confirmation of what has been evident in Illinois for some time, namely that Middle Mississippi is the result of southern influence and represents a period of expanded population in this State. At the same time, Ford and Willey find evidence for the sudden disappearance of this large population just before the entrance of the early explorers. They remark, "In areas where sites of the early and late Middle Mississippian cultures must have numbered in the thousands, not an Indian was to be found in the latter part of the 17th century when French and English explorers entered the region. This is probably true for the Mississippi and Ohio valleys and for much of the country covered by the Tennessee–Cumberland and Lamar cultures."[2] Archaeological evidence from Illinois seems to uphold this conclusion, since the numerous Middle Mississippi sites have never yielded any trade materials.

Ford and Willey have used a number of criteria, which we cannot discuss now, to assign general dates to the periods which they have outlined. The latest dates, which are the most reliable, are the ones with which we are concerned. They set the time of Temple Mound I in Illinois as from 1500 to 1600, and Temple Mound II as from 1600 to 1700. These are of course only approximate.

ARCHAEOLOGICAL AND HISTORICAL RELATIONSHIPS

We are now able to approach the main area of interest of this paper. We have seen how the archaeological time sequence has been constructed to take us almost up to 1700. At the same time, historical records take us back to 1673, the date of the journey of Père Marquette. It would seem, then, that we

might possibly be able to bridge the gap and connect archaeology to history. This paper is an effort to gather evidence which will enable us to determine the unknown relationship of archaeological cultures to the historically known groups which were found in this State.

In the following pages we will attempt to show a relationship between the Illinois confederacy and three archaeological cultures, Maples Mills, Middle Mississippi, and Oneota. We will try to show the historical events and cultural influences which operated upon the Illinois over a period of nearly two hundred years, and led them to change their culture twice within this time. Because we begin with the historic period and work backward, our account from here on will move from late to early times.

The Illinois were a group of confederated Algonkian tribes who at the beginning of the historic period occupied southern Wisconsin, northern Illinois, and sections of Iowa and Missouri. The principal groups in the confederacy were the Cahokia, Kaskaskia, Michigamea, Moingwena, Peoria, and Tamaroa. Marquette first met a group of the Illinois in Iowa near Des Moines, and a year later met either the same group or a branch of them on Peoria Lake. Joliet's map of 1674 shows the Illinois and Peoria Indians a short way up the Des Moines River, and the Peoria also at Lake Peoria, and the Kaskaskia Indians near Utica. Franquelin in 1684 again places the Illinois village at Utica and shows several groups of the Miami within a few miles of this village. He does not show the Peoria village but does place Fort Crève Coeur at a point where Tonti found the Peoria village, and we know that a village did exist at the fort. These maps show the Kickapoo Indians on the Rock River and the Mascouten Indians on the upper Fox River. Other accounts refer to the Cahokia and Tamaroa settlements near present East St. Louis.

With the exception of the Cahokia and Tamaroa Indians, the groups referred to in the French accounts were all in northern Illinois. The various reports show the same tribal groups in widely separated localities and also show that eastern tribes like the Miami were in northeastern Illinois at the same time as were the Illinois. The Winnebago, Sauk, and Fox groups seem to have been confined to Wisconsin or at least to the area north of the Rock River at this time, although there are references to visits between the Winnebago and the Illinois. It is to be noted that although the Illinois tribes were supposed to have been the principal inhabitants of the entire Illinois country, there are only half a dozen villages noted by the French. The population was declining rapidly when the French arrived, for in 1694 the Kaskaskias abandoned their village near Utica and joined the Peorias, and in 1700 went to the site on the Mississippi below St. Louis which bears their name.[3]

Maret in 1712 remarked that "In a very great extent of country scarcely three or four villages are found."[4] Charlevoix in 1721 speaks of "the little that remains of this nation (Illinois)."[5] It would seem that we have here the final stage of that depopulation of the country which began in late prehistoric times. This means also that the Illinois as a significant group had disappeared at the very beginning of the European contact period and were replaced by the Kickapoo, Pottawatomie, and other tribes who came in from the north and east. If we are to look for Illinois remains, then, we must expect them to date from the time immediately prior to European contact to a very short time after contact. This would be the period from about 1650 to 1725.

We now must turn to another area for more relevant material. In Iowa, Minnesota, Wisconsin, Missouri, Arkansas, and Kansas there has been found an Upper Mississippi culture known as Oneota. This has been identified in Wisconsin with Winnebago, in Iowa with the Oto, and in Missouri with the Missouri. The Oneota culture has been correlated with the Chiwere Sioux by James Griffin and his hypothesis seems to be supported by the above evidence. This does not mean that other groups may not have been influenced by the Oneota culture.

In northern Illinois there have been found a series of Oneota sites. They exhibit the same traits which are diagnostic of Oneota elsewhere: the sites are large and seem to indicate a concentrated settlement but for a short time; pottery is shell-tempered with rectilinear incised, trailed, and punctate designs; often the lip is notched or finger impressed; there is no cord roughening. Vessels are round-

bottomed, with straight or recurved rims and two or four handles. Projectile points are small, triangular, and unnotched. Other characteristic implements are the grooved hammerstone, paired sandstone shaftsmoothers, platform disc pipes, incised catlinite tablets, antler arrowshaft straighteners, and bone harpoons. Burials are extended in open cemeteries or small mounds.[6]

These Oneota sites in Illinois cannot be attributed to the historic invasions by the Winnebago as almost all of these sites are precontact, or show very small amounts of trade material, and the Winnebago when they moved south of the Rock River had many European materials. This same objection applies to the other tribes, the Fox, Sauk, and Pottawatomie, who came into the Illinois country after 1725. This would mean that the Oneota sites in northern Illinois, the last major archaeological group, must be attributed to the Illinois tribes still remaining there 1650-1725.

If this is true, we must explain how it happened that an Algonkian group like the Illinois acquired a culture which belonged in neighboring states to Siouan tribes with whom the Illinois were often fighting. This can be done by reference to the historic events which immediately preceded the coming of the French. Prior to 1655 the Illinois tribes occupied almost all of the area of the present state bearing their name. At about that time the Iroquois began a series of raids into the Illinois country which continued until 1667. In these raids the Iroquois had the great advantage of being armed with guns and metal weapons obtained by trade with the English on the Atlantic coast. The Iroquois raids were motivated by the desire to cut off French trade from direct contact with the inland tribes, with whom the Iroquois were conducting indirect trade in furs. The Iroquois had by 1667 driven the remnants of the Illinois to the west bank of the Mississippi and had disturbed all of the tribes of the Middle West.[7] The shifting of tribal pressure also brought about attacks by the Sauk and Fox from the north. Marquette first found the Illinois in Iowa and records that they moved back to the Illinois River in the following year.[8] Joliet in 1674 shows two villages of Illinois Indians on the Des Moines River near villages of the Ponca and Omaha.[9] Here there was intimate contact between the Illinois and Siouan groups which had Oneota culture. In the south the Michigamea moved into Missouri where they seem to have been in close contact with the Quapaw, a branch of the Missouri Sioux. In 1680 LaSalle listed the Quapaw as members of the Illinois confederacy,[10] and in 1761 DuPratz found the Michigamea and other Illinois bands living with the Quapaw.[11] These facts indicate that the Illinois were on friendly if not intimate terms with the Quapaw and must have been influenced by their culture.

Here we have the historical conditions which could lead to a shift in Illinois culture. The raids by the Iroquois and resulting pressure from other tribes uprooted the Illinois from their settled existence and drove them into close contact with the Oneota Siouan groups. By the time the French explorers arrived, most if not all of the Illinois bands had adopted Oneota culture. Here the descriptions of early Illinois customs are significant because they describe certain features which are present in Oneota and are not found in any other culture known in Illinois. Marquette speaks of the calumet. "It is made of a polished red stone, like marble, so pierced that one end serves to hold the tobacco, while the other is fastened on the stem, which is a stick two feet long, as thick as a common cane, and pierced in the middle. It is ornamented with the head and neck of different birds of beautiful plummage; they also add large feathers of red, green, and other colors with which it is all covered."[12]

This is clearly a type of ceremonial pipe which is well known in Siouan and other plains groups. The important point for us is that Marquette has described a polished red stone pipe probably of catlinite. The only culture known in Illinois which might have such pipes is the Oneota. Marquette also refers to the use of buffalo horn spoons and extensive hunting of bison.[13] Buffalo remains are noticeably scarce in village sites in this area but do occur at Oneota sites. This has been explained in terms of a relatively late migration of the buffalo.

Although Griffin notes that Oneota is similar in many ways to Middle Mississippi, there has not until recently been any clear evidence of a close tie between

the two. This link has been supplied by the Crable site, which is located at the southern tip of Fulton County, near Bluff City. The Crable site shows a composite culture made up almost equally of Spoon River (Middle Mississippi) and Oneota (Upper Mississippi) traits. Combined with these is a series of traits such as tripod vessels, stone "scepters," and engraved shell gorgets which seem related to Ford's "Buzzard Cult" and seem to be derived from the south, possibly the Missouri-Arkansas area. Crable differs from previously known Oneota sites in that it shows an obvious blending of Oneota with another culture and in that it contains no European trade material. The fact that most Oneota sites are contact sites means that the Oneota complex is a late development, presumably after 1650. The absence of trade material at Crable means that this site is one of the earlier manifestations of Oneota culture. This conclusion is strengthened by the presence at Crable of two unassimilated complexes, Oneota and Spoon River. Following the hypothesis of this paper, we would explain Crable as the result of contact with Oneota Siouan groups by a group bearing Spoon River culture. Crable also contains material related to the Buzzard Cult complex of the lower Mississippi valley. These materials must reflect a contact with more southern groups. As previously mentioned, the Illinois had many contacts with the Quapaw, and the latter would, by their geographic position, be qualified as the transmitter of southern influence. It is true that no connection has yet been shown between the Quapaw or Missouri groups and the Buzzard Cult, but it must be remembered that the only Missouri sites identified are from the eighteenth century, after the cult had disappeared. The place to look for the desired combination of traits would be in the town sites along the Mississippi near Memphis.

The years in which the circumstances existed that could produce the combination found at Crable may be the key for putting in chronological order many of the cultural changes which were occurring so rapidly in late protohistoric times. Granting the assumption made here, Crable must have been inhabited at a time when the Buzzard Cult, a reaction to the declining population and the breakdown of the old culture, was popular; after the Illinois had started to adopt a new culture because of increased contact with tribes in the west; but before European trade material had become common enough to be found in archaeological remains. This could have occurred only between the years 1660 to 1725. The actual closing date may be earlier than 1725 because Crable was not mentioned in the French accounts.

The situation at Crable may thus be interpreted as showing a change from a Middle Mississippian or Spoon River culture to the Upper Mississippian Oneota culture. This must not be thought of as taking place in a sharp clearcut manner without previous influence between the cultures. There are indications of contact with Oneota in sherds from Kingston Lake, Fv49, and from Fv237. Bone implements such as the elk or bison scapula hoe are suggestive of Oneota influence. The extent of such contact in particular sites may prove to be a means for placing Spoon River sites in sequence among themselves.

We have now traced the Illinois tribes to the period where their culture was Middle Mississippian. The question may be raised as to how an Algonkian people like the Illinois happened to be Mississippian in culture while related Algonkians were Woodland. The answer to this seems to lie in the geographic position of the Illinois. Living as they did along the Mississippi and Illinois rivers, they were especially susceptible to influences from the lower Mississippi valley. The expansion of Mississippian culture in the Temple Mound I stage would have had a great impact on the Woodland groups which came into contact with the new culture. It was formerly thought that Middle Mississippi in Illinois represented an actual migration of brachicephalic peoples into an area occupied by dolicocephalic stock. This seems to be true only in part, as the Middle Mississippian skulls from Fulton County show a hybrid population in this respect. Further evidence on that point comes from the Maples Mills culture. Here we have a late but prehistoric Woodland group which exhibits strong Mississippian influence. In some cases it has been thought to represent a resurgence of Woodland culture after the Mississippian occupation. However the internal devel-

opment of Maples Mills is toward the acceptance of Mississippian forms and techniques which would indicate that the Woodland culture was being assimilated by the Mississippian. This may represent the period in which the Illinois abandoned Woodland and took over the new Middle Mississippian pattern. This thesis is supported by the fact that many Middle Mississippian sites contain Maple Mills material in intimate association. This condition exists from Fulton County to Aztalan in Wisconsin. It is entirely possible that in the early period certain bands of the Illinois who had become Mississippian in culture lived side by side with other bands who still retained Maple Mills culture.

Summary

The ancestral groups of the Illinois confederacy bore a Woodland culture as did the neighboring Algonkian groups. The Illinois were influenced heavily by southern Mississippian culture because of their location along the river trade routes. They adopted Middle Mississippian culture completely in the course of a century or more. The Maples Mills culture is the expression of the contact period between Middle Mississippian and Woodland patterns and reflects the abandonment of Woodland traits. At the beginning of the 17th century the Illinois bore what is known as the Old Village culture and occupied the territory from the southern tip of the State to Aztalan in Wisconsin. By the middle of the century they had been driven south of the Rock River and had concentrated along the Illinois River. At this time their culture was what we know as the Trappist focus, in Fulton County the Spoon River focus. At this time the Iroquois began their expansion and drove the Illinois into close contact with Oneota Siouan groups west of the Mississippi. This hastened the adoption of Oneota culture although there had been borrowing before. After the Iroquois withdrew in 1667 the Illinois moved back into their ancestral territory. The Crable site is one of the first settlements from this wave of repopulation. Other Oneota sites in Illinois date from the same time or slightly later, and end shortly after 1700, when the Illinois either disappeared or adopted European culture.

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PAPERS IN BOTANY

FROM THE REPORT OF THE SECTION CHAIRMAN

Seven of the twelve papers listed on the program were presented at the Jacksonville meeting; one was read by title only and the other four were not given. One additional paper was presented.

Nine of the thirteen papers are published herein, the others were:

JONES, G. NEVILLE, Urbana, Ill., *The Genus Viola in Illinois.*

SPAETH, J. NELSON, Urbana, Ill., *The Older Forest Plantations of Illinois.*

TIFFANY, L. H., Evanston, Ill., *Oedogonia from Southern Florida.*

WYND, F. L., Urbana, Ill., *Cellular versus Organismic Physiology of the Vitamins.*

DR. L. WALLACE MILLER, Illinois State Normal University, Normal, Illinois, was elected chairman for the year 1943-44. Attendance at the meeting was 22.

(Signed) K. RICHARD JOHNSON, *Chairman*

NATURAL REFORESTATION OF STRIP MINES OF SALINE COUNTY, ILLINOIS

CLARENCE BONNELL

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The workable veins of coal which underlie the northern half of Saline County, Illinois, crop out along a northeast-southwest line southwest of Harrisburg, the county seat. Harrisburg is near the center of the county.

Prior to 1900, slope mining was carried on in a few places in hillsides along this outcrop. Later a number of shaft mines were operated in the deeper coal north of the outcrop. The depth of the coal is increasingly greater north of the outcrop and reaches depths of 500 and 600 feet at the north boundary of the county.

The first mining with steam shovels in this vicinity began some three miles southwest of Harrisburg about 1925. Stripping is a means of recovering coal which lies within 10 to 60 feet of the surface, usually where the overburden is too weak to permit mining from shafts. Slope tunnels occur where the depth of the coal is greater and the cover permits. Some strip mines extend to areas which have been mined-out from shafts farther north.

At the Sahara Coal Company's great washing plant several miles southwest of Harrisburg, both strip and slope mining are done on a scale much greater than was done by smaller companies in the period some 15 to 20 years ago. At Sahara No. 5, the No. 6 coal is brought to the surface by an endless conveyor from a slope mine which operates in coal too deep to be obtained by stripping. Another vein under the strip is also brought out by the belt system. The endless belt in long slopes will probably be used in the future when the deep coal beyond the old shaft mines is taken out from northern Saline and southern Hamilton counties.

Artificial planting of black locust, pines, etc., is carried on by Sahara and other large companies in the more recent stripping operations. This gives promise of much success.

This account has to do more particularly with the unplanted early strips mentioned above where Nature has taken over reforestation of the abandoned dumps which stripping with steam shovels has left southwest of Harrisburg.

Trees, mostly cottonwoods, ranging up to six inches in diameter may be seen from State Highway No. 34 at the extreme east end of these early workings. The prevalence of this species here is probably due to the ease with which wind borne seed were scattered, though there is a claim that some seeds were scattered by man and even that small trees were set.

There is every reason to believe that black locust, walnut, hickory, elm, and other valuable native species would be growing among the cottonwoods if their seeds had been distributed.

A considerable area has recently been leveled by use of power machinery. One mining engineer estimated that such leveling could be done at a cost of fifty dollars an acre in normal times. Excellent gardens have been grown on some of these dumps where rainfall and capillary action from below are the only sources of water. Berries and fruit trees should grow well here. A peach tree in full blossom and an apple tree with buds just bursting were seen a few weeks ago at another location on the dump.

Drainage ditches bordering the southern edge of the dumps at a point where operations began earlier than at the area just described have an abundant growth of native species which have been seeded by water carriage in addition to wind and animals. It is only a question of time till seeds from these ditches and from growths along land lines will be carried to the higher lying hummocks. Trees 30 feet high stand on a near-by land line which was entirely cleared of timber a generation or two ago.

Further southeast, there is a good showing of young ash trees on the very top of a dump where a source of seed has been near enough for transportation by natural means.

Fig. 1.—A typical reforestation strip mine.

Still further southeast, elm, and oak with cottonwoods of greater diameter than the trees mentioned before are found. This is where the earliest stripping was done nearly 20 years ago. This is at the "Blue Hole," a strip of water three eighths of a mile long, where the steam shovel made its last trip. It is bounded on the north by a clay bank of undisturbed top soil and on the south by the dump of soil and shale taken from it.

The "Blue Hole" gets its name from the color of its clear water. Some say that is due to copperus in the water but good fishing is supplied by bass, crappie, bluegills, and catfish. It is frequented by bathers. Some drownings have occurred there.

Back of the first line of humps from the water and between it and others there is a broad level area which apparently was used by trucks in getting coal out. This has a fine growth of sweet clover. The humps on either side grow it also. The material in this locality is clay and shale with no limestone but it is sweet enough to grow legumes abundantly.

Whenever the scarcity of land in the vicinity will justify the cost of leveling, men will take over the area for fruits and ordinary farm crops. Areas which are not leveled and are let alone will eventually produce a succession of trees which will be similar to the natural growth which originally covered all of Saline County. Parts of the area may be taken over for pasture land without leveling.

Whether such strips will be made level and again used for general farming or left as they are and planted in trees, they will eventually be returned to use. If the processes of Nature go on unassisted, they will at last become forests. There is nothing more permanent than the land. Man may abuse it or overturn it but it will eventually revert to its original state of fertility if left alone. Only where it is washed away is it lost. Most strip mines operate on level land where washing away is of less importance.

A PRELIMINARY CHECK LIST OF THE VASCULAR PLANTS OF SANGAMON COUNTY, ILLINOIS

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Sangamon County is situated near the southwest part of the prairie portion of the State of Illinois, popularly known as the "Corn Belt." Its surface is a nearly level plain, rather deeply dissected by the Sangamon River and its branches. The upland plain was originally covered with a rich vegetation of prairie grasses whereas forests occupied the stream valleys. These forests seem to have occupied nearly one-third of the entire area of the county. At present practically all of the upland and more than half of the stream valleys are cultivated fields. Small remnants of prairie vegetation are to be found along the railway right-of-way. Some of the forested valleys remain, but most of the valuable timber has been removed.

For some unexplained reason the county has produced no scientist interested in its rich flora, and few botanical collectors seem to have visited its field, hence its plant life has been relatively unknown. Therefore, during the seasons of 1940 and 1941, the Illinois State Museum undertook to explore the extent of the flora. By means of collectors obtained through the WPA, every one of the townships of the county was visited repeatedly during the two growing seasons and some 4000 plant specimens were taken which have been preserved in the herbarium of the Illinois State Museum. Since the project was interrupted in 1942, due to lack of collectors, it seemed desirable to publish this incomplete preliminary check list of some 870 species. In compiling this list the nomenclature of Deam's "Flora of Indiana" has been followed, supplemented by Hitchcock's "Manual of Grasses of the United States," and Rehder's "Manual of Cultivated Trees and Shrubs Hardy in North America," (Second Edition).

OPHIOGLOSSACEAE

Botrychium obliquum Muhl.
" virginianum (L.) Sw.

POLYPODIACEAE

Cystopteris fragilis (L.) Bernh.
Onoclea sensibilis L.
Dryopteris hexagonoptera (Michx.) C.Ch.
Dryopteris thelypteris (L.) Gray
Polystichum acrostichoides (Michx.) Schott.
Asplenium platyneuron (L.) Oakes.
Adiantum pedatum L.

SALVINIACEAE

Azolla caroliniana Willd.

EQUISETACEAE

Equisetum arvense L.
" fluvitile L.
" prealtum Raf.

TYPHACEAE

Typha latifolia L.

SPARGANIACEAE

Sparganium eurycarpum Engelm.

POTAMOGETONACEAE

Potamogeton pectinatus L.
" spp.

ALISMACEAE

Alisma subcordatum Raf.
Echinodorus radicans (Nutt.) Engelm.
Sagittaria latifolia Willd.

GRAMINEAE

Bromus ciliatus L.
" commutatus Schrad.
" purgans L.
" secalinus L.
" tectorum L.
Festuca octoflora Walt.
Glyceria striata (Lam.) Hitchc.
Poa annua L.
" compressa L.
" pratensis L.
" spp.
Eragrostis cilianensis (All.) Link
" frankii Meyer
" hypnoides (Lam.) BSP.
" pectinacea (Michx.) Nees
" spectabilis (Pursh) Steudel
Uniola latifolia Michx.

GRAMINEAE *cont.*

Phragmites communis Trin.
Dactylis glomerata L.
Triodia flava (L.) Hitchc.
Agropyron repens (L.) Beauv.
Elymus canadensis L.
" villosus Muhl.
" virginicus L.
Hordeum jubatum L.
" nodosum L.
" pusillum Nutt.
Hystrix patula Moench.
Lolium perenne L.
Sphenopholis intermedea (Rydb.) Rydb.
Calamogrostis canadensis (Michx.) Beauv.
Agrostis alba L.
" perennans (Walt.) Tuck.
Cinna arundinacea L.
Phleum pratense L.
Aristida oligantha Michx.
Eleusine indica (L.) Gaertn.
Spartina pectinata Link.
Muhlenbergia mexicana (L.) Trin.
Leersia oryzoides (L.) Sw.
" virginica Willd.
Digitaria ischaemum (Schreb.) Muhl.
" sanguinalis (L.) Scop.
Panicum capillare L.
" dichotoma L.
" dichotomiflorum Michx.
" latifolium L.
" miliaceum L.
" scribnerianum Nash.
" virgatum L.
" villosissimum Nash.
Echinocloa crusgalli (L.) Beauv.
Setaria lutescens (Weigel.) Hubb.
" viridis (L.) Beauv.
Andropogon furcatus Muhl.
" scoparius Michx.
Sorghastrum nutans (L.) Nash.

CYPERACEAE

Cyperus diandrus Torr.
" filiculmis Vahl.
" rivularis Kunth.
" strigosus L.
Scirpus americanus Pers.
" atrovirens Muhl.
" cyperinus (L.) Kunth.
" lineatus Michx.
" validus Vahl.
Eleocharis obtusa (Willd.) Schultes
" tenuis Kunth.
Carex alopecoides Tuck.
" aurea Nutt.
" blanda Dewey
" cephalophora Muhl.
" cepheloidea Dewey
" cristatella Britt.
" davisii Schw. and Torr.
" frankii Kunth.
" gravida Bailey
" grayii Carey
" grisea Wahl.

CYPERACEAE *cont.*

Carex hirsutilla Mack.
" laxiflora Lam.
" lunelliana Mack.
" lupulina Nutt.
" monile Tuck.
" normalis Mack.
" pallescens L.
" pennsylvanica L.
" platyphylla Carey
" plana Mack.
" rosea Schkuhr.
" scoparia Schkuhr.
" shortiana Dewey
" sparganoides Muhl.
" tribuloides Wahl.
" vulpinoidea Michx.

ARACEAE

Arisaema dracontium (L.) Schott.
" triphyllum (L.) Schott.

LEMNACEAE

Spirodela polyrhiza (L.) Schleid.
Lemna trisulca L.
" minor L.

COMMELINACEAE

Commelina communis L.
" erecta L.
Tradescantia canaliculata Raf.
" subasper Ker.
" virginiana L.
" virginiana var. rosea

JUNCACEAE

Juncus brachycarpus Engelm.
" effusus L.
" macer Gray
" nodosus L.
Luzula multiflora (Ehrh.) Lejeune

LILIACEAE

Uvularia grandiflora Smith
Hemerocallis fulva L.
Allium canadense L.
" cernuum Roth.
" tricoccum Ait.
" vineale L.
Nothoscordum bivalve (L.) Britt.
Erythronium albidum (Nutt.)
" americanum (Ker.)
Camassia scillioides (Raf.) Cary
Ornithogallum umbellatum L.
Muscari botryoides (L.) Mill.
Asparagus officinalis L.
Smilacina racemosa (L.) Desf.
" stellata (L.) Desf.
Trillium nivale Riddell
" recurvatum Beck.
Polygonatum biflorum (Walt.) Ell.
" pubescens (Willd.) Pursh
Lilium superbum L.
Smilax ecirrhata (Engelm.) Wats.
" herbacea L.
" hispida Muhl.
" rotundifolia L.

AMARYLLIDACEAE

Hypoxis hirsuta (L.) Coville

DIOSCOREACEAE

Dioscorea villosa L.

IRIDACEAE

Iris virginica L. var. shrevei (Small) Anderson
Belamcanda chinensis (L.) DC.
Sisyrinchium albidum Raf.
" angustifolium Mill.
" graminoides Bickn.

ORCHIDACEAE

Orchis spectabilis L.
Spiranthes gracilis (Bigel.) Beck
" cernua (L.) Richard
Liparis liliifolia (L.) Richard

SAURURACEAE

Saururus cernuus L.

SALICACEAE

Populus alba L.
" deltoides Marsh.
Salix alba L.
" amygdaloides Anders.
" humilis Marsh.
" interior Rowlee
" nigra Marsh.

JUGLANDACEAE

Juglans cinerea L.
" nigra L.
Carya cordiformis (Wang.) K. Koch
" glabra (Mill) Sweet
" laciniosa (Michx. f.) Loud.
" ovata (Mill.) Sweet
" tomentosa (Lam.) Nutt.

BETULACEAE

Carpinus caroliniana Walt.
Ostrya virginiana (Mill.) K. Koch
Betula nigra L.

FAGACEAE

Quercus alba L.
" bicolor Willd.
" borealis Michx.
" imbricaria Michx.
" macrocarpa Michx.
" muhlenbergii Engelm.
" palustris Muench.
" velutina Lam.
" marilandica Muench.

ULMACEAE

Ulmus americana L.
" fulva Michx.
Celtis occidentalis L.

MORACEAE

Morus alba L.
" rubra L.
Maclura pomifera (Raf.) Schneid.
Humulus americanus Nutt.

MORACEAE *cont.*

Humulus japonicus Sieb. & Zucc.
" lupulus L.
Cannabis sativa L.

URTICACEAE

Urtica procera Muhl.
Laportea canadensis (L.) Gaud.
Pilea pumila (L.) Gray
Boehmeria cylindrica (L.) Sw.
Parietaria pennsylvanica Muhl.

SANTALACEAE

Comandra richardsiana Fern.

ARISTOLOCHIACEAE

Asarum canadense L.

POLYGONACEAE

Rumex acetosella L.
" altissimus Wood
" crispus L.
" verticillatus L.
Polygonum aviculare L.
" amphibium L.
" buxiforme Small
" coccineum Muhl.
" convolvulus L.
" hydropiper L.
" lapathifolium L.
" monspeliense Thieb.
" orientale L.
" pennsylvanicum L.
" persicaria L.
" punctatum Ell.
" scandens L.
" virginianum L.

CHENOPODIACEAE

Atriplex patula L.
Chenopodium album L.
" ambrosioides L.
" boscianum Moq.
" berlandieri Moq.
Kochia scoparia (L.) Schrad.
Salsola pestifer Nelson

AMARANTHACEAE

Amaranthus blitoides Wats.
" graecizans L.
" hybridus L.
" retroflexus L.
" spinosus L.
Acnida altissima Riddell
" altissima var. subnuda (Wats.) Standley
" tamariscina (Nutt.) Wood
Froelichia gracilis (Hook.) Moq.

NYCTAGINACEAE

Oxybaphus nyctagineus (Michx.) Sweet

PHYTOLACCACEAE

Phytolacca americana L.

AIZOACEAE

Mollugo vertillata L.

PORTULACACEAE

Claytonia virginica L.
Portulaca oleracea L.

CARYOPHYLLCEAE

Stellaria longifolia Muhl.
" media (L.) Cyril.
Cerastium arvense L.
" nutans Raf.
" vulgatum L.
Arenaria lateriflora L.
" serpyllifolia L.
Paronychia canadensis (L.) Wood
Agrostemma githago L.
Silene antirrhina L.
" latifolia (Mill.) B. and B.
" nivea (Nutt.) Otth.
" noctiflora L.
" stellata (L.) Ait.
" stellata var. scabrella Nieuwl.
Lychnis alba Mill.
Saponaria officinalis L.
" vaccaria L.

NYMPHAEACEAE

Nelumbo pentapetala (Walt.) Fern.
Nuphar advena Ait.

CERATOPHYLLACEAE

Ceratophyllum demersum L.

RANUNCULACEAE

Hydrastis canadensis L.
Isopyrum biternatum (Raf.) T.&G.
Actaea alba (L.) Mill.
Aquilegia canadensis L.
Delphinium ajacis L.
" tricorne Michx.
Anemone canadensis L.
" cylindrica Gray
" virginiana L.
Anemonella thalictroides (L.) Spach.
Hepatica acutiloba DC.
Clematis pitcheri T.&G.
" viorna L.
" virginiana L.
Myosurus minimus L.
Ranunculus abortivus L.
" fascicularis Muhl.
" hispidus Michx.
" pennsylvanicus L.
" recurvatus Poir.
" septentrionalis Poir.
Thalictrum dasycarpum F.&L.
" dioicum L.
" revolutum DC.

BERBERIDACEAE

Podophyllum peltatum L.
Caulophyllum thalictroides (L.) Michx.
Berberis vulgaris L.

MENISPERMACEAE

Menispermum canadense L.

ANONACEAE

Asimina triloba (L.) Dunal.

LAURACEAE

Sassafras albidum (Nutt.) Nees.
Benzoin aestivale (L.) Nees.

PAPAVERACEAE

Sanguinaria canadensis L.
Papaver rhoes L.

FUMARIACEAE

Dicentra canadensis (Goldie) Walp.
" cucullaria (L.) Bernh.

CRUCIFERAE

Lepidium campestre (L.) R.Br.
" virginicum L.
Thlaspi arvense L.
Sisymbrium officinale (L.) Scop.
" altissimum L.
Brassica juncea (L.) Cosson.
" nigra (L.) Koch.
Barbarea vulgaris R.Br.
Iodanthus pinnatifidus (Michx.) Steud.
Roripa sessiliflora (Nutt.) Hitchc.
" palustris (L.) Bess.
Nasturtium officinale R.Br.
Armoricia rusticana Gaertn.
" aquatica (Eaton) Wieg.
Cardamine bulbosa (Scherb.) BSP.
Dentaria laciniata Muhl.
Capsella bursa-pastoris (L.) Medic.
Draba reptans (Lam.) Fern.
Descurainia brachycarpa (Rich.) Schulz.
Arabis canadensis L.
" dentata T.&G.
" lyrata L.
" virginica (L.) Poir.
Erysimum cheiranthoides L.
Hesperis matronalis L.
Conringia orientalis (L.) Dumort.

CAPPARIDACEAE

Polanisia graveolens Raf.

CRASSULACEAE

Sedum ternatum Michx.
Penthorum sedoides L.

SAXIFRAGACEAE

Heuchera hirsuticaulis Wheelock
" hispida Pursh.
Hydrangea arborescens L.
Ribes missouriense Nutt.

PLATANACEAE

Platanus occidentalis L.

ROSACEAE

Aruncus dioicus (Walt.) Fern.
Malus ioensis (Wood) Britt.
Amelanchier canadensis (L.) Medic.
Crataegus crus-galli L.
" farwellii Sarg.
" margaretta Ashe
" mollis (T.&G.) Scheele
" punctata Jacq.
" pruinosa (Wendl.) Koch
" spp.

ROSACEAE *cont.*

Rubus allegheniensis Porter
" hispidus L.
" occidentalis L.
" villosus Ait.
" spp.
Fragaria virginiana Duchesne
Potentilla argentea L.
" arguta Pursh.
" monspeliensis L.
" recta L.
" simplex Michx.
Geum canadense Jacq.
" macrophyllum Willd.
" strictum Ait.
" vernum (Raf.) T.&G.
" virginianum L.
Agrimonia gryposepala Wallr.
" parviflora Ait.
" pubescens Wallr.
" rostellata Wallr.
Rosa blanda Ait.
" carolina L.
" palustris Marsh.
" setigera Michx.
Prunus americana Marsh.
" hortulana Bailey
" lanata (Sudw.) M.&B.
" mahaleb L.
" persica (L.) Stokes
" serotina Ehrh.

LEGUMINOSEAE

Cassia fasciculata Michx.
" marilandica L.
Cercis canadensis L.
Gleditsia triacanthos
Gymnocladus dioica (L.) Koch
Baptisia leucantha T.&G.
Medicago lupulina L.
" sativa L.
Melilotus alba Desr.
" officinalis (L.) Lam.
Trifolium agrarium L.
" hybridum L.
" procumbens L.
" pratense L.
" repens L.
Psoralea onobrychis Nutt.
" tenuiflora Pursh.
Amorpha canescens Nutt.
" fruticosa L.
Petalostemum candidum (Willd.) Michx.
" purpureum (Vent.) Rydb.
Tephrosia virginiana (L.) Pers.
" virginiana var. holoserica (Nutt.) T.&G.
Robinia pseudo-acacia (L.) Pers.
Astragalus canadensis L.
Desmodium acuminatum (Michx.) DC.
" canadense (L.) DC.
" canescens (L.) DC.
" dillenii Darl.
" illinoiense Gray
" nudiflorum (L.) DC.
" paniculatum (L.) DC.
" viridiflorum (L.) Beck.

LEGUMINOSEAE *cont.*

Lespedeza capitata Michx.
" hirta (L.) Horem.
" intermedia (Wats.) Britt.
" procumbens Miehx.
" violacea (L.) Pers.
" virginica (L.) Britt.
Vicia villosa Roth.
Lathyrus ochroleucus Hook.
Amphicarpa bracteata (L.) Fern.
Apios americana Medic.
Strophostyles helvola (L.) Britt.
" leiosperma (T.&G.) Piper

GERANIACEAE

Geranium bicknellii Britt.
" carolinium L.
" maculatum L.

OXALIDACEAE

Oxalis europaea Jordan
" grandis Small
" stricta L.
" violacea L.

ZYGOPHYLLACEAE

Tribulus terrestris L.

RUTACEAE

Zanthoxylum americanum L.
Ptelea trifoliata L.

POLYGALACEAE

Polygala sanguinea L.
" verticillata L.

EUPHORBIACEAE

Croton glandulosus L.
Acalypha ostryaefolia Riddell
" virginica L.
Euphorbia corollata L.
" cyparissias L.
" dentata Michx.
" geyeri Engelm.
" glyptosperma Engelm.
" heterophylla L.
" maculata L.
" marginata Pursh
" supina Raf.

LIMNANTHACEAE

Floerkea proserpinacoides Willd.

ANACARDIACEAE

Rhus glabra L.
" radicans L.
" typhina L.

CELASTRACEAE

Evonymus atropurpureus Jacq.
Celastrus scandens L.

STAPHYLEACEAE

Staphylea trifolia L.

ACERACEAE

Acer negundo L.
" nigrum Michx. f.
" saccharinum L.
" saccharum Marsh.
" saccharum var. rugelii (Pax) Rehder

HIPPOCASTANACEAE

Aesculus glabra Willd.

BALSAMINACEAE

Impatiens biflora Walt.
" pallida Nutt.

RHAMNACEAE

Rhamnus lanceolata Pursh
Ceanothus americanus L.

VITACEAE

Vitis aestivalis Michx.
" cinerea Engelm.
" riparia Michx.
Parthenocissus quinquefolia (L.) Planch.

TILIACEAE

Tilia americana L.

MALVACEAE

Abutilon theophrasti Medic.
Malva rotundifolia L.
Callirhoe triangulata (Leavenw.) Gray
Napaea dioica L.
Sida spinosa L.
Hibiscus militaris Cav.

HYPERICACEAE

Hypericum mutilum L.
" perforatum L.
" prolificum L.
" punctatum Lam.
" sphaerocarpum Michx.

CISTACEAE

Lechea tenuifolia Michx.
Helianthemum canadense (L.) Michx.

VIOLACEAE

Viola arvense Murr.
" canadensis L.
" ericarpa Schwein.
" missouriensis Greene
" palmata L.
" papilionacea Pursh
" pubescens Ait.
" rafinesquii Greene
" scabriuscula Schwein.
" sororia Willd.
" sagittata Ait.
" striata Ait.
" tricolor L.

LYTHRACEAE

Ammannia coccinea Rottb.
Lythrum alatum Pursh
Cuphea petiolata (L.) Koehne

ONAGRACEAE

Jussiaea diffusa Forskal.
Ludwigia palustris (L.) Ell.
" alternifolia L.
Epilobium coloratum Muhl.
Oenothera biennis L.
" cruciata Nutt.
" laciniata Hill
" pilosella Raf.
" rhombipetala Nutt.
Gaura biennis L.
" parviflora Dougl.
Circaea latifolia Hill

HALORAGIDACEAE

Myriophyllum spicatum Fern.
" heterophyllum Michx.

ARALIACEAE

Aralia nudicaulis L.
Panax quinquefolium L.

UMBELLIFERAE

Sanicula canadensis L.
" gregaria Bickn.
" marilandica L.
" trifoliata Bickn.
Eryngium yuccaefolium Michx.
Chaerophyllum procumbens (L.) Crantz.
Osmorrhiza claytoni (Michx.) Clarke
" longistylis (Torr.) DC.
Zizia aurea (L.) Koch.
Cicuta maculata L.
Cryptotaenia canadensis (L.) DC.
Carum carvi L.
Taenidia integerrima (L.) Drude
Perideridia americana (Nutt.) Reichenb.
Sium suave Walt.
Thaspium trifoliatum (L.) Britt. var.
" " flavum Blake
Angelica atropurpurea L.
Oxypolis rigidor (L.) Raf.
Pastinaca sativa L.
Heracleum lanatum Michx.
Daucus carota L.

CORNACEAE

Cornus asperifolia Michx.
" racemosa Lam.

ERICACEAE

Monotropa uniflora L.

PRIMULACEAE

Samolus pauciflorus Raf.
Lysimachia ciliata L.
" lanceolata Walt.
" longifolia Pursh
" nummularia L.
" thyrsiflora L.
Dodecatheon meadia L.

OLEACEAE

Fraxinus americana L.
" lanceolata Borkh.
" pennsylvanica Marsh.
" quadrangulata Michx.

GENTIANACEAE

Gentiana andrewsii Griseb.

APOCYNACEAE

Amsonia tabernaemontana Walt.
Vinca minor L.
Apocynum androsaemifolium L.
" cannabinum L.
" cannabinum var. pubescens (Mitchell) A.DC.

ASCLEPIADACEAE

Acerates floridana (Lam.) Hitchc.
" viridiflora (Raf.) Eaton
Asclepias incarnata L.
" purpurascens L.
" phytolaccoides Pursh
" syriaca L.
" sullivantii Engelm.
" verticillata L.
Gonolobus gonocarpus (Walt.) Perry

CONVOLVULACEAE

Cuscuta gronovii Willd.
" pentagona Engelm.
" spp.
Convolvulus arvensis L.
" repens L.
" sepium L.
Ipomoea hederacea Jacq.
" lacunosa L.
" pandurata (L.) Mey
" purpurea (L.) Roth.

POLEMONIACEAE

Phlox bifida Beck
" divaricata L.
" glaberrima L.
" paniculata L.
" pilosa L.
Polemonium reptans L.

HYDROPHYLLACEAE

Hydrophyllum appendiculatum Michx.
" macrophyllum Nutt.
" virginicum L.
Ellisia nyctelea L.
Phacelia bipinnatifida Michx.

BORAGINACEAE

Heliotropium indicum L.
Cynoglossum officinale L.
Lappula echinata Gilib.
Hackelia virginium (L.) Johnston
Myosotis scorpioides L.
" virginica (L.) BSP.
Mertensia virginica (L.) Link
Lithospermum arvense L.
" canescens (Michx.) Lehm.
" croceum Fern.
" incisum Lehm.

VERBENACEAE

Verbena bracteata Lag. & Rodr.
" hastata L.
" simplex Lehm.
" stricta Vent.

VERBENACEAE *cont.*

" urticaefolia L.
Phyla lanceolata (Michx.) Greene

LABIATAE

Teucrium canadense L.
Scutellaria galericulata L.
" lateriflora L.
" ovata Hill
" ovalifolia Pers.
" parvula Michx.
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
Nepeta cataria L.
Glecoma hederacea L.
Glecoma hederacea var. parviflora (Benth.) House
Prunella vulgaris L.
Physostegia virginiana (L.) Benth.
Leonurus cardiaca L.
" marrubiastrum L.
Stachys asper Michx.
" hispida Pursh
" palustris L.
" tenuifolia Willd.
Salvia lyrata L.
Monarda bradburiana Beck.
" fistulosa L.
" " var. mollis (L.) Benth.
Blephilia ciliata (L.) Raf.
" hirsuta (Pursh) Benth.
Hedeoma pulegoides (L.) Pers.
" hispida Pursh
Pycnanthemum flexuosum (Walt.) BSP.
" pilosum Nutt.
" virginianum (L.) D.&J.
Lycopus americanus Muhl.
" virginicus L.
Mentha arvensis L.
" canadensis L.
" spicata L.
" piperita L.

SOLANACEAE

Physalis heterophylla Nees.
" lanceolata Michx.
" pubescens L.
" subglabrata Mack. & Bush.
Solanum carolinense L.
" dulcamara L.
" nigrum L.
" rostratum Dunal.
Datura stramonium L.

SCROPHULARIACEAE

Verbascum blattaria L.
" thapsus L.
Kickxia elatine (L.) Dumort.
Linaria canadensis (L.) Dumort.
" vulgaris Hill
Chaenorrhinum minus (L.) Lange.
Collinsia verna Nutt.
Scrophularia lanceolata Pursh
" marilandica L.
Chelone glabra L.
Pentstemon digitalis Nutt.

SCROPHULARIACEAE *cont.*

Pentstemon hirsutus (L.) Willd.
" pallidus Small
Mimulus alatus Ait.
" ringens L.
Leucospora multifida (Michx.) Nutt.
Lindernia dubia (L.) Pennell
Veronica arvense L.
" peregrina L.
" serpyllifolia L.
Veronicastrum virginicum (L.) Farw.
Dasistoma macrophylla (Nutt.) Farw.
Gerardia tenuifolia Vahl.
Aureolaria flava (L.) Farw.
" grandiflora (Benth.) Penn.
" pedicularia (L.) Raf.
" virginica (L.) Farw.
Melampyrum lineare Lam.
Pedicularis canadensis L.

BIGNONIACEAE

Campsis radicans (L.) Seeman
Catalpa speciosa Warder

LENTIBULARIACEAE

Utricularia macrorhiza Le Conte

ACANTHACEAE

Ruellia caroliniensis (Walt.) Streud.
" pedunculata Torr.
" strepens L.
Dianthera americana L.

PHRYMACEAE

Phryma leptostachya L.

PLANTAGINACEAE

Plantago aristata Michx.
" lanceolata L.
" major L.
" rugelii Dene.
" virginica L.

RUBIACEAE

Houstonia longifolia Gaertn.
" purpurea L.
Cephalanthus occidentalis L.
Diodia teres Walt.
Spermacoce glabra Michx.
Galium aparine L.
" asprellum Michx.
" circaezens Michx.
" concinnum T.&G.
" pilosum Ait.
" tinctorium L.
" triflorum Michx.

CAPRIFOLIACEAE

Sambucus canadensis L.
Viburnum acerifolium L.
" lentoga L.
" prunifolium L.
Triosteum aurantiacum Bickn.
" perfoliatum L.
Symphoricarpos orbiculatus Moench.
" rivularis Suksdorf.

CAPRIFOLIACEAE *cont.*

Lonicera dioica L.
" sempervirens L.

VALERIANACEAE

Valeriana pauciflora Michx.

DIPSACACEAE

Dipsacus sylvestris Huds.

CUCURBITACEAE

Echinocystis lobata (Michx.) T.&G.
Sicyos angulatus L.
Cucurbita foetidissima HBK.

CAMPANULACEAE

Campanula americana L.
Specularia perfoliata (L.) A. DC.

LOBELIACEAE

Lobelia cardinalis L.
" kalmii L.
" inflata L.
" siphilitica L.
" spicata Lam.

COMPOSITAE

Vernonia altissima Nutt.
" fasciculata Michx.
" missurica Raf.
Elephantopus carolinianus Raenschel.
Eupatorium altissimum L.
" coelestinum L.
" maculatum L.
" perfoliatum L.
" purpureum L.
" rugosum Houtt.
" serotinum Michx.
" sessilifolium L.
Kuhnia eupatorioides L.
Liatris pycnostachya Michx.
" squarrosa Willd.
" spicata (L.) Willd.
Solidago altissima L.
" caesia L.
" canadensis L.
" gigantea Ait.
" gigantea var. leiophylla Fern.
" gilvocanescens Rydb.
" glaberrima Martens
" graminifolia (L.) Salisb.
" juncea Ait.
" latifolia L.
" media (Greene) Bush
" nemoralis Ait.
" rigida L.
" speciosa Nutt.
" ulmifolia Muhl.
Boltonia asteroides (L.) Her.
Aster azureus Lindl.
" cordifolius L.
" drummondii Lindl.
" ericoides L.
" laevis L.
" lateriflorus (L.) Britt.
" novae-angliae L.
" paniculatus Lam.

COMPOSITAE *cont.*

Aster patens Ait.
" pilosus Willd.
" " var. demotus Blake
" sagittifolius Willd.
" salicifolius Willd.
" shortii Lindl.
Erigeron annuus (L.) Pers.
" canadensis L.
" divaricatus Michx.
" philadelphicus L.
" pulchellus Michx.
Antennaria falax Greene
" plantaginifolia (L.) Richards
Anaphalis margaritacea (L.) Gray
Gnaphalium obtusifolium L.
" purpureum L.
Polymnia canadensis L.
Silphium integrifolium Michx.
" laciniatum L.
" perfoliatum L.
" terebinthinaceum Jacq.
Parthenium integrifolium L.
Iva ciliata Willd.
" xanthifolia Nutt.
Ambrosia bidentata Michx.
" elatior L.
" trifida L.
" coronopifolia T.&G.
Xanthium pennsylvanicum Wallr.
Heliopsis helianthoides (L.) Sweet
" scabra Dunal.
Eclipta alba (L.) Hassk.
Rudbeckia hirta L.
" laciniata L.
" " var. humilis Gray
" subtomentosa Pursh
" triloba L.
Brauneria purpurea (L.) Britt.
" pallida (Nutt.) Britt.
Ratibida pinnata (Vent.) Barnh.
Helianthus angustifolius L.
" annuus L.
" divaricatus L.
" giganteus L.
" grosseserratus Martens
" hirsutus Raf.
" microcephalus T.&G.
" occidentalis Riddell
" petiolaris Nutt.
" rigidus (Cass.) Desf.
" scaberrimus Ell.
" strumosus L.
Actinomeris alternifolia (L.) DC.
Verbesina helianthoides Michx.
Coreopsis lanceolata L.
" palmata Nutt.
" tripteris L.
Bidens aristosa (Michx.) Britt.
" bipinnata L.
" cernua L.
" comosa (Gray) Weig.
" discoidea (T.&G.) Britt.
" frondosa L.
" involucrata (Nutt.) Britt.
" laevis (L.) B.S.P.
" trichosperma (Michx.) Britt.
Galinsoga ciliata (Raf.) Blake
Helenium autumnale L.
" nudiflorum Nutt.
Dyssodia papposa (Vent.) Hitchc.
Anthemis cotula L.
Achillea millefolium L.
Matricaria matricarioides (Les.) Porter
Chrysanthemum leucanthemum L.
Tanacetum vulgare L.
Cacalia atriplicifolia L.
" tuberosa Nutt.
Senecio aureus L.
" glabellus Poir.
Erechtites hieraeifolia (L.) Raf.
Arctium minus (Hill) Berhn.
Cirsium arvense (L.) Scop.
" discolor (Muhl.) Spring.
" muticum Michx.
" vulgare (Savi.) Airy-Shaw
Cichorium intybus L.
Krigia biflora (Walt.) Blake
" virginica (L.) Willd.
Tragopogon pratensis L.
Taraxacum officinale Weber
Sonchus arvensis L.
" asper (L.) Hill
Lactuca canadensis L.
" " var. integrifolia (Bigel) Gray
" floridana (L.) Gaertn.
" scariola L.
" spicata (Lam.) Hitchc.
" villosa Jacq.
Pyrrhopappus carolinanus (Walt.) DC.
Prenanthes alba L.
" crepidinea Michx.
Hieracium gronovii L.
" longipilum Torr.
" scabrum Michx.
" venosus L.

PRELIMINARY REPORT ON THE BRYOPHYTES OF BOIS BLANC ISLAND

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The bryophytes listed are from a collection made in one day on Bois Blanc in July 1942. The trip was made possible by Dr. William Campbell Steere from the University of Michigan Biological Station at Cheboygow, Michigan.

All identifications made by the writer were checked by Dr. Steere. Many specimens not listed have yet to be checked.

HAPATICAE

Ptilidiaceae
- Ptilidium pulcherrimum (Web.) Hampe
- Trichocolea tomentella (Ehrh.) Dumort

Harpanthaceae
- Lophocolea minor Nees
- Chiloscyphus fragilis (Roth) Schiffn.
- Chiloscyphus pallescens (Ehrh.) Dumort

Jungermanniaceae
- Jungermannia lanceolata L.

Porellaceae
- Porella platyphylloidea (Schwein.) Lindb.

Radulaceae
- Radula complanata (L.) Dumort.

Frullaniaceae
- Frullania eboracensis Gottsche

Lejeunaeceae
- Lejeunea cavifolia (Ehrh.) Lindb.

Marchantiaceae
- Marchantia polymorpha L.

MUSCI

Tetraphidaceae
- Tetraphis pellucida Hedw.

Polytrichaceae
- Polytrichum jumiperinum Hedw.

Fissidentaceae
- Fissidens adiantoides Hedw.

Ditrichaceae
- Ceratodon purpureus

Dicranaceae
- Dicranum flagellare Hedw.
- Dicranum montanum Hedw.
- Dicranum ovide (Sull & Lesq.) Lindb.
- Dicranum rugosum (Hoffm.) Brid.
- Dicranum scoparium Hedw.
- Oncophorus Wahlenbergii Brid.

Leucobryaceae
- Leucobryum glaucum (Hedw.) Schimp.

Buxbaumiaceae
- Buxaumia aphylla Hedw.

Pottiaceae
- Barbula convoluta Hedw.
- Barbula unguiculata Hedw.
- Tortella tortuosa (Turn.) Limpr.

Funariaceae
- Funaria hygrometrica Hedw.

Orthotrichaceae
- Orthotricum speciosum Nees.
- Ulota crispa (Hedw.) Brid.

Aulacomniaceae
- Aulacomnium palustre (Web. & Mohr.) Schwagr.

Bartramiaceae
- Philonotis fontana (Hedw.) Brid.

Bryaceae
- Bryum caespiticum (L.) Hedw.
- Bryum argenteum (L.) Hedw.
- Pohlia nutans (Hedw.) Lindb.
- Pohlia Wahlenbergii (Web. & Mohr.) Andrews
- Rhodobryum roseum (Bry. Eur.) Limpr

Mniaceae
- Mnium affine Bland.
- Mnium cuspidatum Hedw.
- Mnium spinulosum Bry. Eur.
- Mnium punctatum Hedw.

Hypnaceae
- Climacium Americanum Brid.
- Calliergonella Schreberi (Bry. Eur.) Grout
- Campylium hispidulum (Brid.) Mitt.
- Drepanacladus aduncus (Hedw.) Bry. Eur.

Hypnum reptile Mx.
- Hypnum curvifolium Hedw.
- Pylaisia Selwynii Kindb.
- Phytidiadelphus triquetrus (Hedw.) Warnst.

Leskeaceae
- Thuidium delicatulum (Hedw.) Mitt.

Neckeraceae
- Neckera pennata Hedw.

Leucodontaceae
- Leucodon sciuroides (Hedw.) Schwaegr.

PRAIRIES AND FORESTS OF McLEAN COUNTY, ILLINOIS

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Lucy Braun says that the prairies of Adams County, Ohio, owe their entrance and establishment to past conditions, that they are relic colonies, and that they entered the region at a time unlike the present. She goes on to say that certain vegetational remnants found at Mineral Springs are the result of a warm dry climate leading to the establishment of a prairie climax.

Homer C. Sampson in 1921 says in regard to the Prairies of Illinois, "The depressions, resulting from the formation of moraines across preglacial valleys became postglacial lakes and sloughs which were slowly drained. In general the moraines became forested, but many of the lakes and sloughs through gradual filling and draining became prairies." However, he makes no explanation of the origin of this phenomenon.

George H. Lane, writing of his pollen studies in north central Iowa in 1931 says, "Climatic changes inferred from changes in the vegetation as determined from pollen analysis are, (a) *warming* from 15 ft. to 10 ft., (b) *gradual drying* from 15 ft. to 8 ft. and (c) *grassland* climate above 8 ft.—of distinctly arid type at 8 ft. and at the 5, 4, and the 3 foot levels. No indication was found of recent increase of forests although recent conditions appear to be more humid than those at the 3 ft. level."

"There is no indication from this study that the forest is replacing grassland in Central Iowa."

Weaver says that "the prairie that lies within the climate of the deciduous forest is the sub-climax prairie, which in general represents an eastward movement of the climax prairie into the region of deciduous forest because of reduced rainfall."

Voss has shown by pollen analysis studies that spruce, pine, and fir were the common species in northern Illinois shortly after the retreat of the ice and that these species were followed by oaks and hickories.

When the early pioneers came to McLean County, they found that the oaks and hickories had been largely replaced by sugar maples and that the wet parts of the country were covered with tall grass prairies.

If we assume that the changes in the postglacial climate were from cool and moist to a warmer and then to a very dry climate followed by recent increases in humidity, then the presence of a maple forest on the moraines and of wet tall grass prairies on the lower areas can easily be interpreted.

In the shallow ponds and lakes that were left after the melting of the glacial ice, the submerged, the floating, the reed swamp and the sedge meadow stages of vegetation would follow in succession in spite of the gradual increase of warmth and atmospheric dryness. When the sedge meadow stage was ready to give way to the next stage in vegetational development, forest trees would have invaded if the climate had not become too xerophytic for the growth of pioneer tree species. Since the climate had become so continental, it was only natural for the tall slough grass and other wet prairie plants to possess the newly made water soaked humus.

When once slough grass became well established, it raised the level of the ground and made a place for the climax *Andropogons* and other typical prairie plants. It was climax for the xerophytic phase of the postglacial climate.

Later as the climate became favorable for forest trees to develop, trees were free to invade the prairie where ever they could get in.

D. P. White in 1941 says that black prairie soil full of humus developed under grasses is short in phosphorus and potassium and probably lacks the needed microrhiza that may aid in the establishment of trees.

At the time the wet prairies were developing under the influence of a xerophytic climate the forests on the moraines

were dominated by oaks and hickories. Because they were well established and because the water-table was high, there was a sufficiently favorable microclimate under the trees to allow the oaks and hickories to replace themselves under their own shade.

When the climate became more humid and less xerophytic, sugar maples replaced the oaks and hickories. This is as we have it now in such places as Funk's Grove. Under this less xerophytic and more humid climate the prairie grasses were able to hold their own against the invasion of trees.

The xerophytic climate was not rigorous enough, nor did it last long enough time to do away with the deciduous forest but on the other hand it came at a time that was critical in the development of the vegetation of low wet areas and it lasted long enough to allow the tall grass prairies to become so well established that in spite of the fact that when the climate became less continental so as to allow trees to invade the prairies, only man has been able to destroy them.

THE USE OF PRAIRIE RELICS IN TEACHING

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The prairies of Illinois formerly occupied slightly more than 50 per cent of the total area of the State. It is a climax vegetation characterized by its tall grasses and many flowering herbaceous plants, and in Illinois occupied an eastern lobe of a narrow belt extending from Canada to Texas. Throughout the area there is little or no effort being made to preserve this distinctive vegetation. Due to the favorable topography of most of the prairie land, and particularly to the high fertility of the soil, it has become the most productive and valuable farming section in Illinois as is shown by agricultural statistics. This land, therefore, has been highly prized by the farmer and has been subjected to rather thorough cultivation during the past 70 years with the result that the prairie as a complete flora is practically non-existent and its representatives are rapidly disappearing.

Few undisturbed open areas in the prairie sections exist today. Some prairie species still occur together in isolated areas or relics along railroads, roadsides, and borders of lightly pastured woodlots where many introduced plants intermingle, unfortunately making the flora atypical. There are usually other ecological factors present somewhat different from those found in the original prairie.

It is highly desirable that these prairie remnants be preserved and enlarged. Several large tracts set aside for the conservation of the prairie adjacent to one or more of our wooded state parks would prove highly educational and of inestimable value to the State as a whole. Some type of conservation effort is urgently needed in order that we may retain and know some of the charm of early Illinois and may provide opportunity to study many of the physiological and ecological aspects of this peculiar and hardy flora.

Science teachers in our public schools have many opportunities to draw the attention of young people to this fascinating flora. Certainly the prairie has greatly influenced the social and economic development of the State, and enough remains to merit its analysis and consideration. A study of soil profiles, root ecology, transpiration rate, relative humidity, and other ecological features of the prairie and the forest will contribute much to an understanding of the great differences in humus content and fertility of forest and prairie soils under cultivation. Although the conditions permitting the existence of the prairie may be largely buried in the past, a study of the climate, the environmental complex as a whole, and the xeric aspect of the prairie flora strongly suggest the importance of water loss in the air and water supply in the soil. Taxonomic study, gathering of specimens for school herbaria, and the making of photographic records of prairie species is fascinating and has great future value.

TOTAL NITROGEN AND VITAMIN C IN OATS GROWN AT DIFFERENT LEVELS OF SOIL MOISTURE

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The problem of the rôle of water in the development of plants is of considerable scientific interest and economic importance. Early experiments were concerned with the growth and composition of plants in relation to irrigation practices. More recently studies have been made on the internal water economy of plants in relation to physiological development. Loehwing *(3)* found at the time of flower inception in hemp, beans and other herbaceous annuals, a rather abrupt increase in the rate of transpiration. An earlier experiment *(4)* has shown this phenomena to occur in cereal grasses. This experiment was carried out with two varieties of spring oats—Kherson and Illinois 30-2088 grown under normal long-day conditions (13-15 hours of light). Since spring oats are considered a long-day plant, the present experiment was planned to observe the behavior of spring oats under short-day conditions.

The Kherson variety of spring oats was used. They were grown under cultural conditions similar to those in the previous experiment. The pots were seeded on Nov. 17, 1941, and the soil-moisture levels were adjusted 15, 22.5, 30, 37.5 and 45 per cent. The plants received natural day light that amounted to 9-12 hours of light per day. Samples of the plants were taken periodically during the growth period and the fresh tissue was analyzed for vitamin C by titrating with 2,6-dichlorophenolindophenol *(6)*. Other samples were dried and total nitrogen determined by the micro-Kjeldahl method of Pregl *(5)*. The results given are the average of duplicate determinations. At each sampling date, several stems were dissected in order to study the morphological changes of the growing point.

The previous experiment *(4)* had indicated that under normal long growing conditions spring oats will start to joint about twenty-eight days after seeding. At the jointing stage, the internodes elongate and the growing point begins floral differentiation. In the present experiment, the jointing stage was never attained and the growing point remained in a vegetative condition. The number of leaves formed under normal long-day conditions is usually six or seven. In the present experiment ten to twelve leaves were formed by the plants grown at all moisture levels except those growing in the 15 per cent soil-moisture series which formed seven or eight leaves.

The earlier experiment had demonstrated that the jointing stage was accompanied by an abrupt increase in the rate of transpiration. The plants in the present experiment did not exhibit this abrupt rise in transpiration. Dissection of the stem and an examination of the growing point at the various sampling dates showed no flower inception.

Burd *(2)*, Bakhuyzen *(1)*, and others have shown that at the stage of flower inception, plants undergo a change in their internal water relationships. Tissue analyses indicated a lower water content and a higher percentage dry weight. This tissue dehydration is accompanied by profound chemical changes —minerals, insoluble protein, and reserve polysaccharides are mobilized. The data (table 1) for green and dry weights per plant do not show evidence of tissue dehydration noted in plants in a reproductive condition.

Total nitrogen per plant and vitamin C per plant increase during the growing period of the plant. The highest total nitrogen per plant was found in the plants growing in the soil with 30 per cent moisture. The highest vitamin C per plant was found in the plants growing in the soil with 45 per cent moisture. The best growth as indicated by green and dry weight per plant was found in the plants growing in the soil with 37.5 per cent moisture.

The data indicate that spring oats, growing at different soil-moisture levels, under short-day conditions remain in a vegetative condition, and that their tissues retain the chemical characteristics typical of the preflowering stage.

TABLE 1

	15% Soil Moisture					22.5% Soil Moisture					30% Soil Moisture				
	Green weight per plant	Dry weight per plant	Total N per plant	Vitamin C Dry	Vitamin C per plant	Green weight per plant	Dry weight per plant	Total N per plant	Vitamin C Dry	Vitamin C per plant	Green weight per plant	Dry weight per plant	Total N per plant	Vitamin C Dry	Vitamin C per plant
	gm.	gm.	mgm.	mgm. %	mgm.	gm.	gm.	mgm.	mgm. %	mgm.	gm.	gm.	mgm.	mgm. %	mgm.
12-10-41	.24	.022	1.30	435	.0087	.25	.023	1.35	421	.0089	.25	.023	1.35	389	.0083
12-13-41	.295	.026	1.52	411	.0095	.302	.027	1.63	375	.0093	.345	.029	1.73	367	.0089
12-17-41	.322	.032	1.64	382	.0122	.385	.035	1.85	372	.0119	.45	.040	2.15	346	.0124
12-19-41	.308	.035	1.79	342	.0136	.471	.041	2.13	438	.0157	.531	.043	2.30	448	.0157
12-22-41	.284	.039	1.94	296	.0162	.544	.044	2.26	431	.0144	.667	.051	2.68	423	.0165
1-13-42	.406	.066	2.56	386	.0420	1.19	.116	4.72	390	.0451	1.508	.132	5.40	427	.0495
1-17-42	.64	.09	3.59	428	.0543	1.34	.138	5.10	390	.0535	1.77	.170	6.68	401	.0655
1-23-42	.71	.10	4.03	382	.0535	1.86	.20	6.82	381	.0621	2.33	.23	8.56	411	.0934
2- 2-42	....	....	....	...	.....	2.25	.30	9.96	318	.127	3.13	.327	11.55	402	.138

	37.5% Soil Moisture					45% Soil Moisture				
	Green weight per plant	Dry weight per plant	Total N per plant	Vitamin C Dry	Vitamin C per plant	Green weight per plant	Dry weight per plant	Total N per plant	Vitamin C Dry	Vitamin C per plant
	gm.	gm.	mgm.	mgm. %	mgm.	gm.	gm.	mgm.	mgm. %	mgm.
12-10-41	.28	.026	1.57	382	.0093	.273	.024	1.40	408	.0086
12-13-41	.338	.028	1.74	362	.0085	.336	.028	1.66	357	.0084
12-17-41	.44	.037	2.00	364	.0114	.45	.040	2.12	340	.0121
12-19-41	.83	.045	2.41	408	.0156	.555	.048	2.51	400	.0167
12-22-41	.669	.050	2.71	425	.0159	.672	.054	2.87	401	.0175
1-13-42	1.78	.144	6.25	470	.0399	1.76	.156	6.15	438	.0665
1-17-42	2.07	.194	8.04	359	.0653	1.90	.190	6.57	366	.0700
1-23-42	2.40	.223	9.18	391	.0883	2.11	.226	7.36	364	.0844
2- 2-42	3.21	.340	10.89	375	.134	2.87	.327	9.38	382	.142

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APPLIED BOTANY AS FUN

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Much ink has been spilled over the division (real or imaginary) of "pure" from applied science.

The thesis which I should like to develop—confining myself to botany, the only field in which I can claim authority—is that the difference between the fields is real but that it lies—not in the methods which are largely identical, not in the basic scientific values which are much the same, not even in volume of practical results which may flow from the seemingly least practical approaches—but in the method of choosing problems; that the difference between pure and applied botany is one not of content but of intent. If you choose your own problem (or think you do) it is pure botany. If your problem is chosen for you or forced upon you by the economic needs of some group, it is applied botany.

I shall contend further that the advantage in some respects lies on the side of applied botany—specifically that if you happen to be made that way, it is more fun.

First of all, applied botany offers variety. I have never made any claims of purposefully pushing outward the boundaries of knowledge, rather have I been pushed around by the exigencies of the period. Yet in my 25 years spent in the service of economic botany, I had few dull periods. I have been associated in the field for longer or shorter times with four of our great outbreaks of plant disease, the chestnut bark disease (the greatest of all), bacterial wilt of corn, downy mildew of tobacco, and the Dutch elm disease.

Geographically as well as botanically, my interests have been forced to range widely. Fortunately, plants grow at the most pleasant seasons. They can be studied in Alaska only in the summer and may well be studied during the winter in Florida or Hawaii. I have, however, found it necessary to work at the South Water Market in Chicago and on the water front of New York at three a. m. in the dead of winter. During studies of spoilage of fruit in transit I spent some days in a superintendent's private car and a good part of one night on top of a freight car crossing Iowa. I have even doubled for five summers as an entomologist, and believe it or not, even entomology is interesting if properly pursued.

On the whole, economic botany tends to be a sociable job. In our more or less futile attempts to control plant diseases during the past 25 years, we have taken some bad beatings, but our company has been numerous and exceedingly good.

I very much hope that I will not be misunderstood when I say that I rate as one of the real advantages of economic botany the opportunity, indeed the compulsion, to take real chances on things that really mean something. I bet but rarely, partly, no doubt, through parsimony, but largely as a result of a conviction that if a thing is not of sufficient interest without a wager, it is not worth bothering with. I note in a book review in the Yale Review for 1938 a sentence referring to the "arid tradition of American culture which compels professors to be accurate and sound rather than interesting and speculative." In the economic field you simply have to take a chance—to act, or refuse to act, which is the same in the end—to pit your own wit against nature and forecast the outcome.

Another of the real advantages of economic botany is that it is perfectly respectable to use plain understandable English. A few years ago I came across (in the December, 1936 Atlantic) an article entitled "The Snobbishness of the Learned" in which this statement was made:

> "The impression that philosophical and scientific ideas cannot be explained in plain language to plain people is . . . due to the fact that philosophers and men of science have not, as a rule, the wit to do it. It is due in plain terms to the stupidity of the learned men and not to the stupidity of humanity."

I believe the charge is unfair, at least I have a strong suspicion that the chief reason so many of our colleagues do not use plain English is that they do not dare, or at least they feel they appear more profound if they are obscure. This is well expressed—as are so many other important truths—by Gilbert and Sullivan. This is from "Patience."

> "If this deep young man expresses
> himself in terms too deep for *me*,
> Why, what a very singularly deep
> young man, this deep young man
> must be."

Of course, sometimes scientific writers go too far even for their associates. Some of you may have read a recent book reivew, which may or may not have been justified. (I have never read the original.) It begins:

> "This book is a fine example of an important and already difficult subject discussed in an abstruse, involved, pompus, and thoroughly tiresome manner. Simple things are made complex, and complex things are made well-nigh incomprehensible."[1]

Finally, economic botany seems to me to be fun because it has human interest. Hans Zinsser refers to this in his recent autobiography, the title of which is "As I Remember Him."

> "The scientist's temporary relief from constant dissatisfaction with his own accomplishments comes from those interludes in which he projects his technical and theoretical training into a problem of practical application."

[1]Copeia, Dec. 26, 1939, p. 240.

Mary E. Pennington expresses the same idea in an interview published in the November 10, 1940 number of "Chemical News."

> "There is a thrill when a scientific idea suddenly strikes home in the form of an industrial problem."

I suppose it all boils down to the universal human need of being important to someone. We all recognize this need in other people and occasionally in ourselves. That is why some people keep dogs, why ladies no longer too young drop their handkerchiefs where we have to pick them up, why neurotic wives throw sick spells. That incidentally, is why honorary societies are organized and perpetuated. Apparently such devices are necessary to sustain the enthusiasm of the scientists themselves. In the economic field there is little or at least much less, need for such secondary stimuli. Indeed, the danger is quite the other way. Scientific work is being held in such high esteem these days that the grave danger is not that we will not be listened to, but that our advice will be taken too seriously and applied with too little restraint.

We can cease to worry about priority in publication when our ideas become common knowledge in an intelligent group almost before they could be published, and in view of the very large percentage of mistakes that each of us is sure to make, it is worth something to be in a field where even mistakes are important.

DISTRIBUTION OF *DIPLODIA ZEAE* AND *D. MACROSPORA* IN THE UNITED STATES

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Two apparently closely related fungi have long been known as causes of ear rots of corn. These are *Diplodia zeae* (Schw.) Lev, first reported in 1822, and *Diplodia macrospora* Earle, described in 1897. So far as can be determined by studies of the fungi in culture, *Diplodia macrospora* is physiologically decidedly inferior. It has a narrower temperature range, it sporulates less freely, and finally it is dependent on outside sources for the biotin necessary to its growth—a product which *D. zeae* is apparently able to produce. Hoppe has proved that when both fungi are allowed to grow on the same ear of corn, *D. macrospora* is unable to compete with *D. zeae*.[2]

In the United States, at least, *D. macrospora* has a more limited range than *D. zeae*. The latter fungus has been reported from California and from every state east of the Rocky Mountains except the three northern New England States. There is one report of *D. macrospora* from Connecticut and two from Delaware, otherwise, all recorded collections are from the south eastern states.

The relation between these two fungi and especially the question of the degree to which *D. macrospora* is able to compete in the field with the apparently more vigorous *D. zeae* has interested me for at least ten years. Most of February and March 1943 was spent in collecting in the states of Tennessee, Mississippi, Louisiana, Texas, and Oklahoma in order to gather further information on this point. The material gathered has now been examined and the fungi identified. In this summary, however, the results have been combined with all earlier available reports of examinations of large numbers of specimens of these two fungi. These included all reports by Eddins[1] from Florida, by Larsh,[4] based on my own collection in several southern states, and Hoppe's[3] reports covering several years of cultures made from diseased kernals, as well as information sent in a personal letter by J. Harvey McLaughlin from Oklahoma. This lumps together isolations from stalks and from kernels as well as reports of various years. So far as can be determined from an examination of tabulated figures this involves no significant error. When all the figures referred to have been included the numbers are fairly large, certainly much larger than in most records of fungi. They vary from 60 in Louisiana to well over 1100 from Tennessee. They thus may not be strictly comparable but they seem large enough to be significant. The exact numbers are as follows: Alabama 425, Florida 975, Georgia 175, Kentucky 254, Louisiana 79, Mississippi 233, Oklahoma 157, South Carolina 123, Tennessee 1148, and Texas 60.

The amount of Diplodia rot varies greatly from year to year,[3] both absolutely and relatively to other fungi. No doubt the relative amounts of the two species of Diplodia fluctuate somewhat also. In Hoppe's cultures from states of Kentucky, Tennessee, Alabama and Mississippi the percentage of *D. macrospora* in relation to all Diplodia isolated was as follows: 1937, 3.1; 1938, 3.9; 1940, 5.7; 1941, 5.5. Chief interest attaches here to the relative amounts of the two fungi in the truly random samples obtained in the field and from cribs and terminals. The relative abundance of *D. macrospora* is expressed as percentage of the entire number of Diplodia specimens examined. Thus zero does not mean that this fungus does not occur in a given state, merely that it was not found in the material examined by the observer. In general it will be noted that the percentage is larger in the states further south. Very likely the percentage indicated for Louisiana is too large due to the small number of specimens collected and to the fact that all of them were made at or south of Baton Rouge.

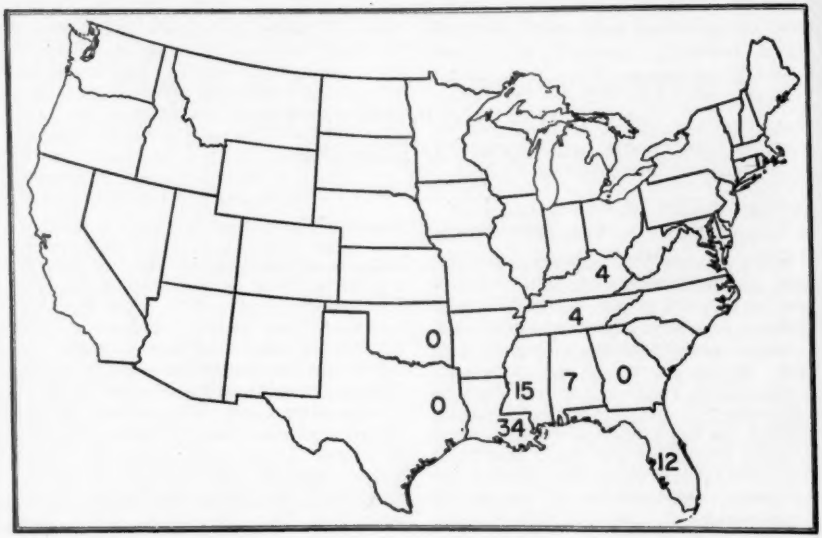

Fig. 1.—Relative abundance of *Diplodia macrospora* and *D. Zeae* on corn expressed as percentage of *D. macrospora*.

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A NEW MUCOR-LIKE FUNGUS FROM PLANT ROOTS

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In 1941, the writer obtained in his laboratory, as a chance isolation from roots of a diseased American elm growing in Peoria, a Mucor-like fungus that was producing both sporangia and zygospores in great abundance. The method of zygospore production revealed that the mold belonged to *Zygorrhynchus*, a genus in which, in contrast with Mucor and Rhizopus, zygospores result from the union of heterogametes formed by a homothallic mycelium. Since no species of this genus has thus far been recorded in Illinois, this account serves first to record this kind of fungus in the State. Also, it describes the Illinois isolation as the type of a new species and offers some observations on the process of zygospore formation.

TAXONOMY

In technical literature six species of *Zygorrhynchus* have been named and described. Five of these are European and one is Japanese. For the most part they have been segregated as species on seemingly trivial characteristics, just as have the species of Mucor and Rhizopus, and the descriptions of them are incomplete.

In America, *Zygorrhynchus* has been isolated a number of times from soils. According to Henrici (1930, pp. 47, 70), because it is active in ammonification, it is one of the most important soil-inhabiting Phycomycetes. With the exception of the isolation made by Povah (1917) in Michigan, which he determined as *Z. Vuillemini* Namysl., American isolations have been classified as *Z. Moelleri* Vuill. Unfortunately, *Z. Moelleri* is the most poorly described of the named species. Vuillemin (1903) distinguished it, as the second species of the genus, almost wholly on certain differences apparent to him between its spores and zygospores and those of *Z. heterogamus* Vuill., the one previously described species. Saccardo[1] may have added confusion by stating the zygospore difference in reverse in the Sylloge Fungorum. Judging, however, from such accounts as that of Grossman (1911), it seems highly improbable that American isolations are the *Z. Moelleri* of Vuillemin. The Illinois isolation certainly is not that species and appears sufficiently distinct from all described species to deserve recognition as another species.

Zygorrhynchus verruculosus n. sp.[2]—Mycelium hyaline (gray in mass), coenocytic, intricately branched but scant and confined to the substratum; main hyphae in age becoming yellowish, 14-16 μ in diameter, densely verruculose, in vigorous growth 8-12 μ in diameter, often verruculose; branches progressively finer and smooth. Chlamydospores abundant, terminal and intercalary, solitary or in short chains, elliptical, oval or subspherical, 13 × 7 μ to 30 × 20 μ. Sporangia abundant, spherical, black, irridescent, 45-55 μ in diameter, apical on hyaline, usually simple but often bifurcate, rarely less regularly branched, densely verruculose sporangiophores 8-10 μ in diameter and 100-300 μ long (when grown in the dark, rare and on sporangiophores many times longer); columella small, spherical to applanate, hyaline, smooth, 15-20 μ in diameter; tunic densely studded with very fine, raphidic spicules, disintegrating completely into innumerable irridescent red, purple and blue particles, leaving no collar. Spores hyaline, oblong-

[1] "Z. Moelleri Vuill.—Bul. Soc. Myc. 1903—A *Z. heterogamo* differt sporis ellipsoideis, 4.3 × 2.6 μ, nec globosis zygosporisque duplo triplove majoribus."

[2] "Zygorrhynchus verruculosus n. sp.—Mycelio hyalino, 8–12 μ vel in aetate lutescente, 14–16 μ diametro, dense verruculoso. Chlamydosporis terminalibus et intercalaribus, 13 × 7 μ ad 30 × 20 μ. Sporangiis sphaericis, nigris, iridescentibus, 45–55 μ diametro, in sporangiophoris simplicibus vel bifurcatis, 8–10 μ diametro, 100–300 μ longis, dense verruculosis latis; columella sphaerica vel applanata, 15–20 μ diametro; tunica minute spiculosa, totaliter disrumpente et collarem non relinquente. Sporis hyalinis, continuis, binucleatis, oblongo-ovalibus et allantoideis, 4.5–5.1 × 2.9–3 μ. Hyphis zygophoris aereis, hyalinis, 5–8 μ diametro, dense verruculosis. Zygosporis globosis, nigris, 45–60 μ, maximo numero 50 μ diametro, denticulis pyramidalibus 6–8 μ altis dense ornatis et cum tympano majore circiter 25 μ diametro porum 1.5–2 μ diametro possidente. Azygosporis nullis.

ovate and noticeably allantoid, binucleate, nonseptate, 4.4-5.1 × 2.9-3 μ. Zygophoric branches aerial, hyaline, 5-8 μ in diameter, densely verruculose. Zygospores globose, black, 45-60 μ, the majority about 50 μ, in diameter at maturity, densely studded with pyramidal denticles 6-8 μ tall, 5-6 μ wide and irregularly stellate at the base; major tympanum about 25 μ in diameter and provided (apparently) with a central pore 1.5-2 μ in diameter. Azygospores not produced.

Obtained from rotting roots (possibly from adhering soil) of *Ulmus americana* L. from Peoria, Illinois, in 1941. Specimen and slides in the Illinois Natural History Survey herbarium, accession number 28927 (TYPE).

In addition to the characters required for technical description, the Illinois isolation displays others, less definite, which seem to set it off from the other species. One of these is its reaction to light in the production of sporangia and zygospores. It has been said of the majority of the earlier species that sporangia occur sparingly. With the Illinois isolation sporangia occur abundantly when cultures are grown in light, a new colony producing hundreds of them in mature condition within three or four days. If, however, cultures are grown in darkness, only a few sporangia develop during a period of many days; then, also, they occur on very long and almost always unbranched sporangiophores. Zygospores, on the other hand, develop slowly in cultures exposed to light. With Van Tiegham cell cultures set up for observation and maintained in a light room, four to six days may pass before zygospores begin to form in numbers, and early stages of zygospore formation exposed to concentrated light while being observed under the microscope are often arrested in development and afterwards make no further progress. Observational microcultures make little or no progress toward zygospore production during daylight hours but produce large numbers of zygospores during the night. On the other hand, new microcultures kept in a dark culture chamber produce zygospores in hundreds and in all stages of development in 36 to 48 hours.

A somewhat distinctive characteristic is seen also in the aberrancies of gametic fusion. In this species, as in others, contact and fusion normally occurs between closely related branches (fig. 15). Nevertheless, a great amount of successful contact occurs between distantly related branches: minus gametophores make contact, and successfully produce zygospores, with plus gametophores arising not only from different aerial branches but even from distinctly separate vegetative hyphae. With this ability is associated an exceptional length of the minus gametophore (as indicated, at least, by the figures of other authors). Also, complete reproductive capacity is often retained in the plus gametophore. This structure not infrequently becomes septate and gives rise to one or more branches which, in turn, produce both plus and minus gametophores and, eventually, normal zygospores.

In the descriptions, or in discussions, of the previously described species there usually is some mention of the production of azygospores. During the two years the Illinois isolation has been under observation, no azygospore has been found in any of the cultures. In this respect, the Illinois isolation differs not only from most of the previously described species but also from some American isolations (Blakeslee, 1904).

The position of the Illinois isolation as a species among the species already described is indicated with some accuracy by the following key, in which the principal distinctions noted by the describers of the other species are given prominence.

KEY TO THE SPECIES OF ZYGORRHYNCHUS

Spores globose, 2.2-2.7 μ in diameter; zygospores usually more than 100 μ in diameter ..... *Z. heterogamus* Vuill.

Spores elliptic, oval or oblong; zygospores much smaller.

Spore elliptical, uniformly small (about 4 μ long) or variable and larger.

Columella pyriform; spores variable (6-10 × 1.5-3 μ); zygospores 68 to 80 μ in diameter ..... *Z. japonicus* Komin.

Columella applanate spherical; spores small.

Zygospores small, usually about 35 μ in diameter; spores 4.3 × 2.6 μ ..... *Z. Moelleri* Vuill.

Zygospores larger, 40-45 μ or up to 60 μ in diameter; spores 4 × 2 μ ..... *Z. Vuillemini* Namysl.

Spore oval or oblong, small.

Zygosporic denticles usually caespitose ..... *Z. Bernardi* Moreau

Zygosporic denticles not caespitose.

Zygospores small, 14-48 μ in diameter; denticles 3-5 μ long, often recurved ..... *Z. Dangeardi* Moreau

Zygospores larger, 45-60 μ in diameter; denticles 6-8 μ long, pyramidal and not recurved ..... *Z. verruculosus* Teh.

A point not given attention in studies made of earlier species is the nuclear condition of the spores. The spores of *Z. Vuillemini* were described as guttulate, those of *Z. Dangeardi* as 1-2 guttulate; but guttules are not characteristically identifiable as nuclei. The spores produced by the Illinois isolation are obviously and clearly binucleate. This fact may indicate that plus and minus nuclei are carried together, but as separate entities, in the coenocytic mycelium from the germination of the zygospore of one generation to the formation of the zygospore of the next generation, even though many reproductions by spores intervene.

Germination of mature zygospores of the Illinois isolation has not been observed. Often, in culture transfers, an apparent germination resembling that reported by Green (1927) has been seen, but it is very doubtful whether this was true germination. Since sporangia are produced freely and are closely intermixed with the zygospores above the surface of the colony, it is possible that spores lodged among the denticles ornamenting the zygospores and, transferred with the zygospores, germinated without being dislodged when presented with fresh medium.

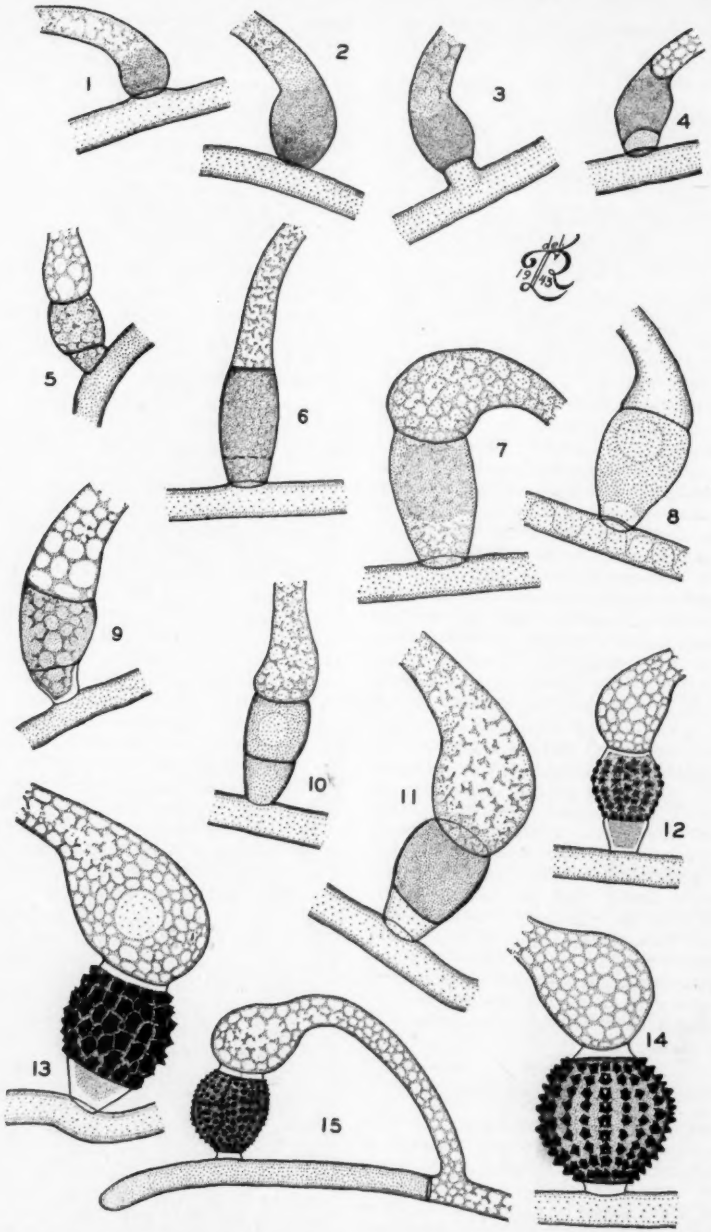
Process of Zygospore Formation

The production of zygospores by species of Zygorrhynchus has received a considerable amount of study, and three views have been expressed by observers, all of whom agree on the major features of the process. These features, described by Vuillemin (1903) and Blakeslee (1904) and later by others, are as follows: From the vegetative mycelium, aerial hyphae arise. These aerial hyphae give rise to lateral branches upon which the zygospores are produced. A lateral branch first becomes divided at some point by a septum that differentiates it into a basal and a distal portion. A branch then arises from the basal portion, just below the newly formed septum, and grows forward, curving back until its tip makes contact, beyond the septum, with the side of the distal portion of the branch from which it arose. At the point of contact, a series of changes takes place and results in the zygospore (fig. 15). It is with regard to this series of changes that investigators have disagreed.

According to Vuillemin (1903), when contact between two zygophoric branches has been made, the distal portion of the original branch produces at the point of contact a short lateral branch which remains apically in contact with the apex of the touching branch. Within this short lateral branch and, simultaneously, within the touching branch walls are laid down, cutting off cells that function as gametes. The gamete cell in the short lateral branch is small while that in the contacting branch is large. Following formation of the gametes, the wall dividing them disappears and, from the two, the zygospore develops. This process has been substantiated in the observations Blakeslee (1904, 1913) made, but appears to have been modified to some extent by the observations of Green (1927), whose account and small inadequate drawings leave some doubt as to how clearly all of the stages, especially the fusion of the gametes, were observed.

Atkinson (1912) at first professed to have found no male gamete. He thought that no male progametangium arose and that the tip of the touching branch fused with the distal part of the original branch, that dissolution of the separating wall occurred, and that direct transfer of protoplasm and nuclei from minus to plus zygophore took place. Later (Blakeslee, 1913) he retracted this view. Grossman (1911), describing an isolation he made in Michigan, expressed essentially the same view, but it may be doubted whether he intended his very brief exposition to be taken literally.

Gruber (1912), expressing a third opinion, believed that, after contact had



Figs. 1–15.—*Zygorrhynchus verruculosus*, n. sp. Stages in conjugation and development of the zygospore. (See p. 113 for explanation of figures.)

been made by the two branches, a branch grew out from the side of the touched hypha, that this branch elongated, that it became divided by a cross wall, and that its terminal cell became swollen and was fertilized by the passage into it of protoplasm and nuclei from the now-swollen end of the touching hypha. According to his view, the minus gametangiophore of Vuillemin and Blakeslee would be the plus gametangeophore and the plus gametangeophore of Vuillemin and Blakeslee would be the minus gametangeophore. Moreau (1912) immediately took exception and claimed that Gruber's interpretation was erroneous.

Of these three interpretations, that of Vuillemin and Blakeslee is generally accepted, owing to Blakeslee's recognized authoritativeness regarding fungi of the Mucorales, to Moreau's denial of Gruber's conclusions, to Atkinson's retraction of his view, and to the later substantiation of Vuillemin's observations by Blakeslee (1913) and by Green (1927). Actual observation of some of the stages is, however, made extremely difficult by both the small size of the cells observed and the obscurity imposed by the early development of cell wall ornamentations. It is not surprising, therefore, that more than one interpretation has been made or that some of the stages have not been clearly observed.[2]

The stages of zygospore formation exhibited by the Illinois isolation have been followed carefully with both actively growing and killed and stained material. To observe growing material, the method used by Blakeslee (1913) was modified by the substitution of Van Tieghem cells for watch glasses and glass covers. A small drop of agar medium, spread thinly while hot over a part of the surface of a coverglass, was inoculated with a small bit of the mold, and the coverglass was then inverted and sealed to the top of the Van Tieghem ring. With a supply of sterile water in the base of the Van Tieghem cell, such a microculture developed well and, especially at the periphery of the coverglass where no medium interfered with light, examples of development could be selected and watched with the ordinary high (44 × or 4 mm.) and sometimes with the oil (97 × or 1.8 mm.) objectives. Since the hyphae on which zygophoric branches occur are almost always aerial, the chief difficulty lay in finding examples suitably oriented for study. Both Blakslee (1913) and Green (1927) have given time schedules with their illustrations of progressive stages; this it has been impossible to do with the present fungus because of its sensitiveness to light.

To obtain material for staining, microcultures were made in small drops of nutrient broth on clean slides. The cultures were placed in inverted sterile Petridishes and the gaps between covers and bottoms of the dishes were sealed with sterile water to maintain a saturated atmosphere in the dishes. These cultures were grown in an incubation chamber into which no light entered. After 36 to 48 hours they were removed and treated for 24 hours with standard formalin-aceto-alcohol solution as a killing agent. Safranin for 24 hours, followed in order by acidified alcohol, ammoniated alcohol, and analine blue in alcohol for two mniutes, proved most satisfactory as a gross structure stain, giving beautifully clear differentiation of chlamydospores, mature sporangiospores, and the swollen zygosporic suspensors. The method would be suitable for the preparation of slides as permanent teaching equipment.

In the Illinois isolation the hyphal apparatus involved in zygospore production is essentially the same as that described for other species. From any point on a vegetative hypha a specialized aerial branch may arise. From this aerial

[2]Regarding actual conjugation, Blakeslee (1913) wrote, "There seems no doubt also that these two gametes . . . unite later by the dissolution of the intervening cross wall into a single cell. . . ."

Explanation of Figures

Fig. 1.—The tip of one zygophoric branch touches and adheres to the side of another zygophoric branch. Fig. 2.—The touching tip becomes large and bulbous. Fig. 3.—The touched branch produces a small outgrowth. Figs. 4–5.—Cross walls separate the bulbous tip and the outgrowth as gametangia. Fig. 6.—The double wall between the gametangia dissolves. Fig. 7.—The fused gametangia begin to enlarge and form the zygospore. Figs. 8–10.—A wall, possibly the endospore, appears in the lower part of the zygospore. Also, swelling of the touching branch above the zygospore becomes pronounced. Fig. 11.—The zygospore wall increases in thickness. Fig. 12.—Dark thickenings appear in the outer wall of the zygospore. Figs. 13–14.—The zygospore increases in size, its polar tympana become evident, and its wall ornaments take form. Figs 15.—The characteristic zygophoric structure, with an immature zygospore.

branch, in turn, lateral branches arise, increase in length for some time, and then produce at their tips two bud-like outgrowths. The two outgrowths appear almost simultaneously. One of them elongates in a forward direction and, although it remains of lesser diameter, appears as a continuation of the branch on which it arose. It is, however, of determinate length, and its contents are soon abjoined by a cross wall, formed near its base, from the contents of its parent branch. The second outgrowth elongates at first in an obliquely forward direction and appears as a lateral branch. Its contents are not, as a rule, abjoined by a cross wall from those of the parent branch. As it elongates, it arches toward, touches, and eventually adheres by its tip to the side of the branch developed from the first bud. When it touches, the zygospore forms (fig. 15).

Immediately after the second branch has touched the first, its tip begins to enlarge (fig. 1). Enlargement continues until a bulbous structure (fig. 2) is formed, in which a dense concentration of protoplasm takes place. At the point of contact between the two branches, the touched branch now produces a short lateral outgrowth (fig. 3) which, as it develops, pushes the touching branch tip backward. This outgrowth, often only 1.5 μ long and rarely as much as 3 or 3.5 μ long, is so short that it can hardly be called a branch. While it is taking form, a cross wall develops in the touching branch in such a position as to separate its bulbously enlarged end as a gametangium. Almost simultaneously a cross wall also develops in the short outgrowth from the touched hypha, usually at or near the level at which the outgrowth originated, to form the other gametangium (figs. 4 and 5).

When the gametangia have thus been defined, their fused walls begin to dissolve (fig. 6). At this stage there usually is not much constriction apparent in the region of the cross walls. With their dissolution, a mingling of cytoplasm and nuclei from the two gametangia occurs and enlargement of the united gametangial cells proceeds rapidly (figs. 7 and 8).

It has not been possible to determine either how much cytoplasm or how many nuclei are contributed by each gametangium. Since one gametangium is small and one is large, it may be supposed that each contributes cytoplasm in proportion to its cubic capacity. The nuclei, during this period, either are too small to be accurately observed or are obscure in the dense cytoplasm. In mature zygospores sectioned two or three months after they had attained full development eight nuclei were counted. Four of these nuclei were large, measuring about 3.5 μ in diameter, while four were small, measuring about 2.2 μ in diameter. They were scattered in the parietal layer of cytoplasm and appeared to have no regular arrangement—at least, there was no grouping together of the small or the large nuclei, no regular alternation in position of large and small individuals, and no obvious pairing.

At an early stage in the enlargement of the united gametangia an indication can be seen that a wall is to be formed in the end connecting with the touched branch (fig. 8). The growth of this wall is accompanied by absorption of protoplasm into the zygote (fig. 9). Although constriction is usually observable where this wall develops, it is questionable whether this wall connects directly with the gametangial wall. It may be the developing endospore.

At this time, or earlier, the touching hypha begins to enlarge in the region next to the zygospore (figs. 5-9) and, as the zygospore grows, continues to swell into a great bulb filled with highly vacuolated protoplasm (figs. 10-15). After union of the gametangia, the touched hypha remains turgid, but it contains little protoplasm and appears to have no function other than that of supplying some mechanical support for the zygospore. The greatly swollen part of the touching branch, which now may be called a suspensor, apparently assumes in full the function of supplying nutriment to the developing zygospore. Also, it soon becomes densely studded throughout with minute, low, nearly hyaline wart-like thickenings. The touched branch remains smooth.

The zygospore, as soon as it begins to enlarge, begins both to thicken its wall (fig. 11) and to initiate on its wall a regular series of thickenings (fig. 12) which develop into pyramidal, black teeth (figs. 13-14). On the mature zygospore (not shown in the figures), these

denticules are regularly spaced and are so numerous that they completely cover the surface of the zygospore. They reach a height of 6 to 8 μ and, at their bases, are irregularly stellate.

For a long time after the zygospore matures, it remains attached to the hyphae that formed it. At the two points of attachment circular tympana, one one large, and one small, separate it from its suspending hyphae. These tympana become evident early in the zygospore's development (fig. 12), remain visible during much of the growth period (figs. 13-15), and are finally hidden when the zygospore approaches full size. Both tympana are hyaline and relatively thick (1.5 μ), and in each there is a central pit or pore through which, it may be supposed, protoplasmic contact and translocation is maintained.

The wall of the mature zygospore consists apparently of the same five layers Vuillemin (1904) destinguished. The outermost layers, two in number, form a dark, hard, denticulated exospore, and the inner layers, three in number, form a hyaline, cartilaginous, smooth endospore. Under pressure the brittle exospore readily breaks into fragments, leaving the zygote enclosed by the tough endospore.

The origin of some of these wall layers is to some extent obscure. The exposure, which includes a dark, very thin cuticular layer and an inner, thick, more or less carbonaceous, denticle-studded layer, develops directly from the original walls of the gametangia. It is continuous with, and represents the same structural unit as, the inclosing wall of the mycelium. The modification of its surface sets it apart, however, as a specialized capsule in which the zygospore is held. The endospore, which consists of a very thin outermost layer (the middle cuticular layer), a thick, elastic, cartilaginous layer, and a very thin, granular innermost layer, could possibly be formed as a series of additions to the inner surface of the exposure. If this were the case, a tight union between exospore and endospore would be expected. Since, however, the two do separate readily, the endospore could be formed by the fused protoplasts from the two gametangia as an entirely new wall serving to separate the zygote as a complete new unit. The meager evidence that has been visible in sectioned material tends to support the view that the endospore is a separately formed unit.

Summary

Occurrence of a fungus of the genus *Zygorrhynchus* in the State of Illinois is reported for the first time. Characteristics of the zygospores, sporangia, spores and mycelium distinguish it from the six described species and, as a new species, it is named *Z. verruculosus*. Its sporangiospores are binucleate and transmit the heterothallic condition through asexual generations. Zygospores are formed in the manner characteristic of the genus. At maturity, they contain eight nuclei, of which four are large and four are small, and are inclosed by an exospore and an endospore. The exospore is formed from the gametangial walls; but the endospore, it is suggested, is formed as an independent structure.

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PAPERS IN CHEMISTRY

FROM THE REPORT OF THE SECTION CHAIRMAN

The Chemistry section program carried ten papers, seven of which are herein published. The others were:

CHERONIS, N. D., Chicago, Ill., *Comparison between small and large group instruction in the teaching of the physical sciences.*

FINGER, G. C., Illinois Geological Survey, Urbana, Ill., *Illinois fluorspar in the war effort.*

REED, F. H., Illinois Geological Survey, Urbana, Ill., *Illinois minerals as chemical raw materials.*

Attendance at the meeting was approximately twenty.

C. W. BENNETT, Western Illinois State Teachers College, Macomb, Illinois, was elected chairman for the year 1943-44.

(Signed) H. W. GOULD, *Chairman*

SOME OBSERVATIONS OF THE INFLUENCE OF SODIUM CARBONATE IN WATER SUPPLIES

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The town of Normal has a water supply containing[1] 400 p.p.m. of total alkalinity and 250 p.p.m. of hardness making the sodium carbonate content, therefore, 150, all calculated as $CaCO_3$ p.p.m. The water is obtained from wells having a depth of approximately 220 feet. The water, as drawn from the ground, contains methane.

When the water is used in apparatus in which concentration due to evaporation may take place, the influence of the sodium carbonate becomes apparent. In the steam boilers of the University heating plant, a constant check on the sodium carbonate content of the boiler water must be made lest boiler plates and tubes be injured. Periodically, samples of the water are titrated for total and caustic alkalinity and the necessary quantity of sodium bisulfate is added to the make-up water to correct the causticity. Dissolved solids are determined by hydrometer, and blow-downs are practiced to keep these solids within limits. If the caustic alkalinity becomes excessive it causes frothing in the boilers, and live steam used at places some distances from the heating plant may have considerable lime and iron compounds entrained. The same frothing tendency is observed in the water still of the David Felmley Hall of Science. Increasing sodium carbonate here may cause such frothing as to carry sediment down the condenser tubes of the still, thereby seriously contaminating the distilled water. Mounting caustic alkalinity in the still boiler is prevented by daily draining and flushing.

The injurious effect of sodium carbonate in boiler waters has been pointed out by Mr. C. C. Williams, superintendent of water and light for the City of Bloomington. His attention was first called to the effect early in 1917 when some cracks near rivets in a boiler shell were observed. The boiler was one of a bank used in the municipal light and water plant. It was operating on water obtained from the Town of Normal. A repairer was employed on the boiler, and he found that the metal, under the torch, failed to flow as good steel does, and moreover had become brittle. Mr. Williams pronounced it a case of caustic embrittlement which was then just coming to be recognized. The early recognition of the failure of the boiler shell probably averted a serious explosion. Because the make-up water for this boiler had come from the Town of Normal supply, there had been a gradual increase in the sodium carbonate content.

In 1917 Stromeyer[2] pointed out that caustic liquors have a deteriorating effect on open hearth and basic Bessemer steels as well as on wrought iron. Merica[3] offered the theory that the failure of the steel was due to absorption of nascent hydrogen, forming an alloy having less ductility than the original steel. He claimed that such failure could be prevented by introducing sodium chromate into the water.

In 1926 and again in 1928 Parr and Straub[4] reported extensive studies on caustic embrittlement of steel. They found that failure was most likely to occur at seams and rivets where there is the combined effect[5] of caustic and stress, and that phosphates, tannates, nitrates and chromates inhibit such action, as well as the maintenance of a ratio of sodium sulfate to sodium hydroxide of 2 to 1. Furthermore, they found that a concentration of 6000 grains of sodium carbonate[6] per gallon (102.6 g per liter) was necessary to produce embrittlement. Straub found no steel is resistant to the embrittling effect of caustic. Since the water supply of Normal contains no sulfates it is obvious that a two-to-one sodium sulfate—sodium carbonate ratio could not operate to prevent embrittling unless some sulfate were added.

The results of the extensive studies by Parr and others offer some explanation of certain boiler failures in the vicinity.

About 1897 there was a disastrous explosion of a steam boiler in Normal used in an electric generating plant. It was operating on the same kind of water as is now supplied by the Town of Normal. A worker in the plant attributed the failure to low water. However, caustic embrittlement may have been an important factor.

In 1912 there was an explosion in the steam plant of the Illinois Power and Light corporation in Bloomington. The boiler that failed was operating on a ground water taken from what is known as the Big Four Valley, which water is of the same general character as that used in Normal. This again may be attributed to caustic embrittlement.

The sodium carbonate content of 150 p.p.m. found in Normal water makes the presence of sulfates of calcium and magnesium impossible and therefore boiler users have no adhering scale. The sodium carbonate does not become troublesome until its concentration is greatly increased. It consumes no soap. Those accustomed to drinking the water come to like it. The removal of the carbonate by use of calcium hydroxide is a simple matter, and this treatment would also remove the calcium and iron present as bicarbonates. This softening program the town expects soon to inaugurate.

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CERTAIN VITAMIN REQUIREMENTS OF BACTERIA

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The existence of a large number of vitamins is now known. Some of these substances were recognized as important in the nutrition of microorganisms before their value in human nutrition was established. It has been known for some time that the addition of liver extract, tomato juice, asparagus juice and similar materials caused an increased growth of microorganisms in culture media. Since these solutions were of indefinite composition the substances causing this increased growth were not definitely known. During the past few years the chemistry of the vitamins has advanced to the point where the chemical structure of many of them is known and they can be obtained for study in bacterial nutrition in pure form. So important are some of these vitamin substances in the nutrition of various strains of bacteria that they fail to grow in a medium that is satisfactory in all other respects.

The work reported in this paper concerns a study of the metabolite (vitamin) requirements of a thermophilic anaerobe, *Clostridium thermosaccharolyticum*. This organism is important in the spoilage of non-acid canned foods. The problem was suggested when it was observed that this organism failed to grow consistently in a new improved anaerobic medium introduced by Brewer (1940).

A medium suggested by Snell and Wright (1941) was chosen. It consists of vitamin-free hydrolyzed casein, cystine, tryptophane, sodium acetate, glucose, adenine, guanine and uracil and a mixture of inorganic salts. In this basal medium the test organism failed to give any appreciable growth or acid production. To this basal medium was added the various vitamins to be tested. Anaerobic conditions were maintained by the addition of reduced iron. The substances tested were water soluble vitamins of the B Complex. In all, eight substances were tested, namely:—thiamin (B_1), Riboflavin (B_2), pyridoxin (B_6) biotin, para amino benzoic acid, nicotinic acid, pantothenic acid and folic acid.

The stock culture was stored in liver infusion medium. Transfers were made to the test medium to which had been added all eight of the substances to be tested. Growth appeared as satisfactory in this test medium as in the liver infusion. The inoculum for tests was prepared by growing the organism through three or more transfers in the hydrolyzed casein media, centrifuging, washing the cells with physiological salt solution, again centrifuging and re-suspending these cells in 99 ml. of physiological salt solution. Two drops of this suspension per tube of medium was used as the inoculum. Since the organism produces an appreciable amount of acid, the effect of each vitamin was measured by titrating the acidity produced.

Two methods were used for testing the vitamin requirements of this organism. In the first series tubes were set up so that the first tube contained all eight vitamins, the second contained only seven and so on until the last tube in the series was basal medium only. A second series was run starting with the basal media and adding first one, then two and so forth until all had been added. Using these two technics it was found that when thiamin, biotin or para amino benzoic acid were omitted from the medium growth and acid production was only slightly better than in the basal medium. In further work it was found that the addition of each of these substances singly to the base medium did not satisfy the requirements of the organism. Combinations of two gave slightly better results, but for maximum acid production all three were required.

After it has been established that these three substances were required, a medium was prepared containing these essential vitamins. Using this as a basal medium the other five substances were added singly and in combination. Riboflavin, pyridoxin and folic acid had no effect on acid production. Nicotinic acid and pantothenic acid alone and when added together gave slight stimulation. From these results it appears that thiamin, biotin and para amino benzoic acid are essential, whereas nicotinic acid and pantothenic acid produce some stimulation but growth and acid production occurs in their absence.

Since the organism responds to thiamin, tests were run to determine its requirements for this vitamin. The basal medium was prepared containing all the necessary substances except thiamin. Thiamin was then added to separate tubes in amounts ranging from .01 micrograms per 10 ml. of medium. Results based on acidity produced indicated maximum acid production when one microgram of thiamin per 10 ml. of medium was used. Acid production decreased as the amount of thiamin was decreased. Addition of amounts greater than 1 microgram per 10 ml. of medium did not increase acid production. No toxicity resulted when as high as 100 micrograms was added.

The thiamin molecule is made up of a pyramidine and a thiazole structure. Certain organisms can use one or the other of these structures to replace thiamin in their nutrition. Other organisms can combine these two compounds when both are present in the medium and thus produce thiamin. Some organisms require the entire molecule. Tests with *Clostridium thermosaccharolyticum* on these two fractions of thiamin indicated that the pyramidine structure cannot be used to replace thiamin. The thiazole fraction is about one-tenth as effective in promoting acid production by this organism. When both substances were added together no greater benefit was obtained than when thiazole alone was added.

In conclusion, it may be stated that *Clostridium thermosaccharolyticum* when grown in a hydrolyzed casein glucose medium requires thiamin, biotin, and para amino benzoic acid. Nicotinic acid and pantothenic acid gave some stimulation but are not absolutely essential. The pyrimidine fraction of thiamin is not utilized by this organism whereas the thiazole fraction gives about one-tenth the value of thiamin.

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INULIN CONTAINING PLANTS AS A SOURCE OF ETHYL ALCOHOL—THE ACTION OF INVERTASE FROM YEAST

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Just as there exists in nature a large group of plants which store starch, we have another large group which store inulin, a polysaccharide somewhat similar to starch but yielding, upon complete hydrolysis, fructose instead of glucose. The best known representatives are the Jerusalem artichoke, dahlia, and chicory. The yields per acre of some of these plants are great enough that they may be considered as potential competitors of present sugar sources. While ordinary brewer's yeast apparently will not attack pure inulin, Windisch,[14] Rudiger[10] and Vadas[13] have reported good yields of alcohol from artichoke tubers without any preliminary hydrolysis. Vadas stresses the fact that if the tubers are cooked, some of the raw pulp should be included to furnish inulase or other enzymes which function in breaking down the complex polysaccharides in the same way that malt breaks down starch. Underkofler, McPherson and Fulmer[12] have recently studied the fermentation of dried artichoke material and report excellent results without a preliminary hydrolysis. Similar findings had been made by Appleman[1] in this laboratory and the work has since been confirmed and extended by Clark.[2]

As early as 1867 Dubrunfaut[5] presented data indicating the presence of sucrose in plants containing inulin. The degradation, or change to simpler nonreducing substances, in the roots or tubers which have been allowed to remain in the ground over winter has been studied by Geslin and Wolf,[6] Colin,[3] Thaysen Baker and Green and De Vito.[4] Evidence for the presence of sucrose is (a) the increase in the reducing sugar as a result of the action of invertase, (b) the lowering of the rotation after hydrolysis, and (c) the presence of aldose sugars as shown by their oxidation by iodine in alkaline solution. However, the actual isolation of the sugar and positive proof of its occurrence seem to be lacking. There is considerable controversy among the workers as to the nature of the materials which may accompany the apparent sucrose.

Before attempting to utilize plants containing inulin as a source of alcohol it is desirable to know as much as possible about the properties of their carbohydrates, particularly as regards their response to the enzymes which occur in yeast.

It was the object of this work, which is preliminary in character, to study the action of invertase as ordinarily applied to the quantitative estimation of sucrose in plant materials and to compare the results with those obtained by the alternate acid hydrolytic method.

Experimental

Plant materials.—The products subjected to analysis were samples of artichoke, chicory and dahlia roots. All were harvested in the late fall and had been washed, sliced in ⅛ inch slices, and dried in a well ventilated oven at about 160°C.

Invertase.—The enzyme was obtained from baker's yeast according to the procedure outlined by Morrow.[9] The product was purified by dialysis in a collodion bag.

Analytical procedure.—The thoroughly dried samples were finely ground in a drug mill. A five-gram portion was weighed into a 400 ml. beaker, 150 ml. of hot distilled water added, the beaker placed on a steam cone and heated for thirty minutes. When the heating period was complete the mixture was filtered, the residue washed, and the filtrate cooled. Neutral lead acetate (8 per cent solution) was added to precipitate the proteins, the mixture was made up to 500 ml. and filtered. To the filtrate enough solid disodium phosphate was added to precipitate the excess lead and the solution was again filtered.

TABLE 1.—APPARENT SUCROSE IN PLANTS CONTAINING INULIN—ANALYSIS OF THE EXTRACT OF THE DRIED MATERIAL

Plant Material	Per cent Apparent Invert Sugar			Total Available Reducing Sugar (Complete Hydrolysis)
	Initially Present	After Invertase Hydrolysis	After Cold HCl Hydrolysis	
Artichoke	1.76	39.1	48.0	
	1.01	25.3	31.8	59.2
	2.00	33.3	37.8	
Chicory	4.10	34.9	48.2	
	4.66	29.4	46.6	48.4
	6.58	37.8	46.9	
Dahlia	6.11	26.7	42.6	
	6.20	34.0	41.7	50.7
	6.54	26.6	42.9	

	Per cent Apparent Sucrose (Average)		
	By Invertase Hydrolysis	By HCl Hydrolysis	Per cent Sucrose by Invertase
			Total Sugar
Artichoke	31.0	37.6	52.5
Chicory	33.2	42.1	68.5
Dahlia	23.0	36.1	45.3

Aliquots of the filtrate were analyzed for reducing sugar by the Munson and Walker method. Other portions were treated for hydrolysis of sucrose by (a) invertase and (b) HCl at room temperature and analyzed according to official methods.[3] The amount of reducing sugar after hydrolysis was estimated by the Lane and Eynon method. From the increase, the apparent sucrose was calculated for the invertase procedure. The total available sugar was established by hydrolyzing at 70° with acid according to the specifications of Jackson and associates[1] and following with a Lane and Eynon titration.

The results are shown in Table 1.

Discussion.—The higher values for apparent sucrose by the acid as compared to the invertase hydrolysis were anticipated. Close agreement of the results from the two methods of treatment would be obtained only if sucrose were present alone or along with materials hydrolyzable only with difficulty. However, the variation in duplicate analyses by the invertase method at first appeared disconcerting. Since the conditions observed for the reaction were adequate for inversion of a quantity of sucrose far in excess of the total sample weight taken, one cannot assign the lack of agreement to incomplete hydrolysis of this sugar. The results suggest that the invertase, as ordinarily prepared, may contain carbohydrases other than sucrose in small amounts which act slowly upon other materials present in the extract. Since repeat analyses made on different days were subject to widely varying temperature conditions (24 hours at room temperature), the extent of these other reactions must have varied considerably. As has been indicated by previous workers, the ready fermentability of the dried material and of the spring harvested crops probably results from a slight degradation of inulin to compounds more susceptible to the action of the yeast.

Entirely apart from the fermentation aspect it should be emphasized that if "invertase" does contain other carbohydrases, the assumption that the system is specific for the sucrose linkage may lead to considerable error when applied without discrimination to the determination of sucrose in plant products.

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SOME NEW SOURCES OF ALUMINUM AND MAGNESIUM

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The sudden demand for light metals for the construction of airships in the national defense has put an enormous burden upon the producers of these metals. The responses have been startling. It has been stated that the present plans for the production of aluminum contemplate turning out from seven to ten times as much metal as was produced in the peak year before the war broke out. In like manner the capacity for the production of magnesium in 1942 was fifty times as great as the consumption in 1935, and in addition plans already announced for the present year contemplate the doubling of the 1942 capacity.

These meteoric developments have raised serious questions regarding our supply of raw material. Both of these metals have formerly been produced from a single source, and in both cases this natural material is limited in quantity. In both cases also we have abundant native compounds which we have never learned to employ for the production of the metal. As a consequence many serious problems have arisen as to possible methods for obtaining these metals from new sources, since these metals are vitally important in winning and maintaining air supremacy in the various battle fronts of the world conflict.

Aluminum was formerly obtained commercially from bauxite, a hydrated oxide which usually contains some iron and silica. The first step in winning the metal from this ore by the universally used Bayer method is digestion of the powdered bauxite with NaOH. This produces soluble $NaAlO_2$ but the Fe_2O_3 is not changed and is effectively removed by filtration. The aluminate is boiled and thoroughly aerated, resulting in the precipitation of $Al(OH)_3$, which is filtered off and ignited to Al_2O_3. This purified alumina is dissolved in a suitable solvent such as fused cryolite, and this solution upon electrolysis yields aluminum metal.

If the bauxite contains silica the alkaline digestion causes a reaction between the SiO_2 and the aluminum compounds producing aluminum silicates. These compounds are stable and the Bayer process does not recover the aluminum metal from them. As a consequence the presence of silica in the bauxite causes the "freezing" of the aluminum with a consequent reduction of the yield. To avoid as much as possible loss from this cause, only bauxite with less than about 7% SiO_2 has been considered suitable for use in the aluminum industry. Deposits of such high grade bauxite are not common and their exhaustion by the present frantic demand for aluminum is imminent. As a consequence there must be found new deposits of high grade bauxite, methods of removing the silica from the low grade bauxite, or practical methods for removing aluminum from the silicate tailings.

An effective washing method of processing bauxite ore for the removal of sand was announced by Alcoa in January 1943. If the process is successful it will do much to extend the production of aluminum because it will make available enormous deposits of low grade bauxite. So far prospectors have uncovered 6,000,-

000 tons of B grade ore, and the search is being continued.

For many years metallurgists have dreamed of the time when it would be possible to extract aluminum from silicate ores at moderate cost. When such a process is devised it will greatly extend our supply of this metal. The tailings of Bayer purification plants will furnish a large supply of material. The East St. Louis plant is said to have a 30-year accumulation of silicate tailings, which would be equivalent to a million tons of bauxite. A lime-soda sintering process has had some success, and it is now proposed to use this treatment for the recovery of aluminum from plants using high-silica bauxite.

Many attempts have been made to extract aluminum from clay and shale. Probably the most successful method so far proposed is the Pedersen process which consists of sintering the clay with limestone and then leaching with soda. Commercial trials of this method are under way. The great advantage which the method enjoys is the fact that it does not require the use of acids. The extraction of aluminum compounds from clay by means of acids has been in use for many years, but when these compounds are used for the production of aluminum metal, costs increase rapidly. But progress in this direction has been so rapid that Donald Nelson has been lead to predict that after August 1943 the United States would be independent of foreign supplies of aluminum ores.

Alunite is a hydrated potassium aluminum sulfate which is found in great abundance in certain areas of the west. Near Marysvale, Utah, there are deposits which are capable of producing 30,000 tons of aluminum metal annually for ten years. Acid extraction of alunite seems to be most promising, and the presence of sulfur in the mineral is an advantage because it permits a plant to extract clay as well as alunite. Pilot plants are now in operation in Utah, at Wilson Dam as well as at other locations. It will be recalled that during World War I it was proposed to extract potash from alunite. If the present emergency results in reclaiming both potash and aluminum from alunite, there will be a great advantage because costs can be distributed between these two useful materials.

The total expenditure scheduled for new aluminum plants in the United States from January 1, 1940 to July, 1943, is estimated at approximately $600,000,000.

Before the outbreak of the present war the sole producer of magnesium in the United States was the Dow Chemical Company, who prepared the metal by electrolysis of fused $MgCl_2$ which was obtained from deep well brines. When it became evident that this source of material could not yield an adequate supply of magnesium, a large plant was built at Freeport, Texas to reclaim $MgCl_2$ from sea water. Later plants were built to use $MgCl_2$ which is prepared by the action of HCl upon magnesite ($MgCO_3$), dolomite ($MgCO_3.CaCO_3$) or brucite ($Mg(OH)_2$). These later methods are expensive because of the quantity of acid required and the inevitable loss which accompanies its recovery.

Since most of the ores of magnesium are carbonates or hydroxides, they are converted to oxides without too great difficulty. Some method of winning magnesium from the oxide seems to be highly desirable. Apparently little effort has been made in this country to obtain magnesium by electrolysis of a solution of the oxide in a fused halide bath. This method has been the favorite one in Germany, which has produced about half of the pre-war magnesium. In the United States and Canada many efforts have been made to produce magnesium by the thermal reduction of MgO.

Prominent among these methods is the Hansgrig process, now being operated by Henry Keiser in a huge plant near San Francisco which has a capacity of 66,000,000 pounds per year. Brucite or magnesite is ignited to the oxide and reduction is accomplished by heating at a high temperature with carbon. The magnesium produced under these conditions is in the vapor phase and must be chilled suddenly to prevent a reverse action. Chilling is accomplished by flooding the chamber with intensely cold hydrogen, natural gas, or fuel oil. This method has encountered some unfortunate handicaps, but now seems to be in successful operation.

The Pidgeon process has been developed under the Canadian National Research Council. As raw material, dolomite may be used. The ore is calcined to

the oxide, and then reduced by ferrosilicon in a vacuum. Dicalcium silicate is formed and pure magnesium condenses without difficulty. This method is said to operate smoothly, to be safe, to require inexpensive equipment and to give excellent metal at low cost.

Another process which looks promising has been devised by Professor Doener of Washington State College. It operates upon low grade magnesite or dolomite, which is first concentrated by a flotation process and then treated by somewhat the same reduction method as is used by the Hansgrig process. The metal is cooled with fuel oil and purified by distillation.

A new magnesium plant near Spokane uses an electric-thermic reduction process which is a modification developed by the U. S. Bureau of Mines. It uses as raw material the magnesite from Stevens County, Washington, and power from the Grand Coulee dam.

Other plants are now in operation or are being completed at Las Vegas, Nevada; Austin, Texas; Lake Charles, Louisiana, and Painesville, Ohio. It is expected that the total capacity for 1942 will reach 100,000 tons annually, and present plans contemplate the doubling of this capacity within the near future.

Because both aluminum and magnesium are relatively new as engineering metals and because they are both light in weight and form strong alloys, it is natural to regard these metals as rivals. It is by no means certain that they will become serious competitors for favor among engineering designers, since each plays a particular part in the design of airplanes. But a comparison of the two metals is interesting.

The electrolytic production of one pound of aluminum requires 12 kilowatt-hours of electrical energy, while a pound of magnesium uses 9.15 kilowatt-hours. Aluminum has a density (2.70) which is a third more than that of magnesium (1.74). Both metals are now selling for the lowest price in history—aluminum pig at 15 cents a pound and magnesium is still quoted at 27 cents a pound although it seems certain that this price may be greatly reduced. These prices seem high for the extensive use of an engineering material, but if the cost per cubic foot is computed it is discovered that aluminum and magnesium by the cubic foot are the cheapest of all our metals with the single exception of iron. The enormous growth of the light metal industries, together with the distinct advantages in their use, make it seem safe to predict that the post-war period will see a great expanse in their use for civilian purposes.

DETERMINATION OF MAGNESIUM

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Reading through the literature on the determination of magnesium, one finds various methods of procedure, and also varying statements regarding the properties of the precipitates formed. Practically all give the $MgNH_4PO_4 \cdot 6H_2O$ method for the separation of the magnesium from the solution, but they differ in the procedure of separation as well as in the method of drying, igniting, and weighing the precipitate.

This research is an attempt to check some of the statements regarding the properties of the precipitates. First, an attempt was made to determine the transition temperatures of $MgNH_4PO_4 \cdot 6H_2O$. The material was prepared by dissolving 20 g. of C.P. $MgCl_2 \cdot 6H_2O$ in about 1500 ml. of distilled water, adding 25 g. of NH_4Cl, making slightly acid with HCl, neutralizing by adding NH_4OH dropwise, adding NH_4OH to 1.5 molar and allowing to stand over night. The precipitate was then collected on a large Buechner funnel, washed free from chlorides, and dried at room temperature (24°C.).

Samples were then placed in a dilatometer tube with C.P. toluene. A check

sample of Rochelle salts was placed in a similar tube, and the two were placed side by side in a bath of glycerol. The temperature of the bath was raised one degree at a time and the readings of the rise in the tube were taken.

The rise per degree was quite uniform in both tubes up to 54°C., when the tube containing the Rochelle salts gave a sudden rise; but no rapid rise in the tube with the magnesium salt was noted until 85-86°C., at which temperature gas bubbles arose, rapidly forcing the liquid out of the tube.

Another method suggested by Hamrich, (J. Chem. Soc. 1589, 1920) was tried. Samples of the two hydrates were placed in toluene in test-tubes with thermometers, in a bath of glycerol. The glycerol bath was heated slowly with an electric heater, and the behavior of the crystals was watched very carefully at each rise in temperature. No change in either tube was noted until 54°C. when the crystals of Rochelle salts could be seen to crack and break down, while drops of moisture could be seen to collect around them. No change could be noted in the magnesium salt until 60°C. when an occasional bubble of gas would form around the crystals; but no noticeable action occurred until 85°, when the bubbling continued for several minutes. The gas given off at this temperature turned litmus blue and was evidently NH_3. Water would not boil off at this temperature and neither was any moisture noted around the crystals, as was noted with the Rochelle salts.

Effect of Heating at Different Temperatures

Six samples were prepared by taking 50 ml. (with a pipette) from a solution of $MgCl_2$ (made up 1 g. Mg. per liter), precipitated as above, and after standing over night, filtered into previously prepared and weighed Gooch crucibles marked A, B, C, D, E, F. After filtering, the samples were washed free from chlorides with 1.5 molar NH_4OH, allowed to dry on the suction for about 15 minutes, and then allowed to stand at room temperatures for one hour. Samples A, B, D, and F were placed in an electric oven at 75°C. Sample C was left in the desiccator over $CaCl_2$. After one hour the samples were removed from the oven, cooled in a desiccator, and weighed: A 0.4438; B 0.3574; D 0.4643, E 0.4952; and F 0.4595. C, which remained in the desiccator at room temperature, weighed 0.5017, which is nearly theoretical for the hexahydrate.

Samples A, B, C, and D were then placed in the oven at 75°C. and left over night. E and F remained in the desiccator. After cooling in the desiccator and weighing: values A 0.2976; B 0.3115; C 0.2955; D 0.3105; E 0.4940; and F 0.4595 were obtained. Samples were again placed in the oven, and the temperature was raised to 85°C. These were left for 24 hours, then cooled and weighed: A 0.2952; B 0.3005; C 0.2898; D 0.3009. These show only slight decrease in weight even at ten degrees rise in temperature. Samples C and D were replaced in the over at 85°C. and left another 24 hours with no further loss in weight.

Further Heating of Samples C and D

24	hours	at	92°	C	0.2858	D 0.2875
24	"	"	115°	"	0.2754	" 0.2773
24	"	"	165°	"	0.2634	" 0.2624
24	"	"	300°	"	0.2458	" 0.2465
24	"	"	500°	"	0.2378	" 0.2380
24	"	"	700°	"	0.2376	" 0.2375
24	"	"	800°	"	0.2376	" 0.2375
24	"	"	900°	"	0.2376	" 0.2375

Loss on heating seemed to be complete at 700°C., as no further loss was noted up to 900°C. Also, 85°C. seemed to be the transition point of some definite compound.

Four more samples were prepared and filtered in the same manner as above, dried by suction, placed in the desiccator, left at room temperature for seven days, then weighed: G 0.4830; H 0.5164; I 0.5144; and J 0.5161. Sample G seemed to be an exception and was left in the desiccator. Sample I, of this set, and sample B, of the former set, were run for N_2 by the Kjeldahl method: I 0.0305 g. N_2 and B 0.0115 g. N_2. Sample I showed nearly the theoretical amount of N_2 for the hexahydrate, while B, which had been heated to 85°C. for 24 hours, lost two-thirds of its nitrogen. This shows that the loss in weight of samples heated above 85°C is not all water of hydration, as many have stated, but is also NH_3. Samples H and J were then heated in the muffle in 24 hour stages with the following results:

24	hours	at	300°	H	0.2476	J 0.2490
24	"	"	500°	"	0.2371	" 0.2383
24	"	"	600°	"	0.2361	" 0.2364
24	"	"	700°	"	0.2361	" 0.2360
24	"	"	800°	"	0.2361	" 0.2360

Another set of six samples were prepared as before. Three were left in the desiccator while the other three were placed in the oven at 60°C. then taken out and cooled in the desiccator and weighed at 24-hour intervals.

24	hrs.	at	60°	K 0.3547	L 0.3476	M 0.3340
48	"	"	"	" 0.3024	" 0.3054	" 0.3040
72	"	"	"	" 0.2994	" 0.3002	" 0.2978
96	"	"	"	" 0.2979	" 0.2992	" 0.2978

Samples of N, I, and B Remaining in Desiccator

48 hours in Desiccator	N 0.5170	I 0.5198	B 0.5226
4 weeks in Desiccator	N 0.5161	I 0.5090	B 0.5200
10 weeks in Desiccator	N 0.5062	I 0.5046	B 0.5176

Samples N and B of the above were run for N_2 with the following results: N 0.308 and B 0.0315. These are just slightly above theoretical for the hexahydrate. Samples K, L, and M came to quite a constant weight after 96 hours at 60°C., supporting a statement by Warshaw that above 50°C., samples of hexahydrate, after 15 days, lost 41.75 per cent of their weight.

Six more samples were prepared as before. Three were placed in the oven at 75°C., and three were left in the desiccator. After 48 hours, the average weight from the oven was 0.2962, and the average weight of those in the desiccator was 0.5133. These samples were then run for N_2. Those from the desiccator averaged 0.0308, and those from the oven averaged 0.0116.

Again, samples heated in the oven over 50°C. and under 85°C. lose about 40 per cent of their weight, as suggested by Warshaw, but of this 40 per cent about two-thirds of their notrogen is included.

Comparison of Hot and Cold Methods

Six samples were prepared hot and made slightly acid with HCl; 40 per cent excess of $(NH_4)_2HPO_4$ was added, the solution was heated to boiling, then NH_4OH from a dropping funnel was added until alkaline, while stirring with an electric stirrer. It was cooled in ice water, made alkaline with NH_4OH to 1.5 molar, stirred for ten minutes, and allowed to stand for 24 hours. These samples were then filtered into prepared Gooch filters, dried, washed, placed in the electric furnace, heated to 900°C., cooled, and weighed. The precipitates were more crystalline than those prepared cold. They filtered more easily, and took less time to wash free from chlorides. The average weight was 0.2276.

Six samples were prepared in the same way except that they were cold. They were washed, dried, placed in the electric oven, and heated to 900°C. The average weight of these was 0.2304. The theoretical value for $Mg_2P_2O_7$ is 0.2289.

Summary

The cooling of the $MgNH_4PO_4{\cdot}6H_2O$ sample should be as rapid as posisble; the precipitation should be kept below 30°C.

The weight is retained for weeks in a desiccator if the temperature has previously been kept below 30°C. However, as much as two-thirds of the NH_3 is lost if the temperature goes above 50°C.

The hot precipitation gives slightly lower results than the cold, but it has the advantage of yielding larger crystals.

PERCHLORIC ACID—A NEGLECTED CHAPTER IN GENERAL CHEMISTRY

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An examination of a dozen or more college textbooks on general chemistry showed that only one of them gave perchloric acid more than passing notice. The omission of this substance from the list of important inorganic compounds cannot be due to any lack of industrial importance. A recent estimate is that 300,000 to 500,000 pounds of perchlorates are produced each month. This puts perchloric acid approximately in the class with phosphoric acid.

The fact that perchloric acid has come into importance only recently may have something to do with its omission. Authors are hesitant about giving space to new compounds as long as there is any question as to their eligibility to a chemical "Who's Who" or "What's What." The compass of textbooks is limited, and "a new topic cannot be squeezed in without squeezing something else out." To displace another topic, a substance must have definite industrial value or scientific significance. For example, if it is an analytical reagent, it must be able to compete with other reagents of recognized standing. This consideration has counted against perchloric acid, for so many analysts are so comfortable in precipitating potassium with chloroplatinic acid that they are unwilling to give a newcomer a trial.

Perchloric acid has a reputation for being a treacherous explosive. A while ago a graduate student argued against including perchloric acid in courses in general chemistry on the ground that its excessive explosiveness would tempt young students to make illicit experiments that might turn out disastrously. This idea of spontaneous explosiveness is not limited to students. It is held by many mature chemists who ought to know better. The fact is, concentrated perchloric acid is quite stable, and cannot be exploded by shock or otherwise. Like nitric acid, it may be used in making explosives. If perchloric acid is to be banned for this reason, consistency would call for a similar exclusion of glycerine and toluene, or even sulfur and saltpeter.

In my opinion, the strongest objection to including perchloric acid in the subject matter of elementary courses is a pedagogical one. Many of the perchlorate reactions that have been studied appear so involved and anomalous, that the student is dismayed and comes to doubt if there are any fundamental principles controlling the course of chemical reactions. An illustration is the awe-inspiring equation proposed for the preparation of perchloric acid from ammonium perchlorate:

$$34NH_4ClO_4 + 36HNO_3 + 8HCl \rightarrow 34HClO_4 + 4Cl_2 + 35N_2O + 73H_2O$$

Other discouraging equations from the literature are:

$$14Fe + 48HClO_4 \rightarrow 14Fe(ClO_4)_3 + 3Cl_2 + 24H_2O$$

$$Cr_2O_3 + 2HClO_4 + H_2O \rightarrow 2H_2CrO_4 + Cl2 + 2O_2$$

PROPERTIES OF PERCHLORIC ACID

Perchloric acid comes on the market as a clear mobile solution, with a density of 1.69, and containing about 72 per cent $HClO_4$. This solution boils at 203° with slight decomposition. Judged by its electrical conductivity, concentrated perchloric acid is a very weak acid. According to Linde, the 72 per cent acid is only 5 per cent ionized. This accounts for its very slow reaction with active metals.

Concentrated perchloric acid is a dehydrating agent and chars wood and other cellulosic materials by the extraction of water. Very naturally, the intensity of this effect varies with temperature.

At ordinary temperatures concentrated perchloric acid is a weak oxidizing agent —not as active as nitric acid. Upon heating to 150° or above, it shows marked oxidizing power, converting Cr^{+++} ions

TABLE 1.—THE REACTIONS OF METALS WITH 72% PERCHLORIC ACID

Metal	Products	Metal	Products
Magnesium	Mg^{++}, H_2	Lead	Pb^{++}, H_2, Cl_2, HCl
Aluminum	Al^{+++}, H_2, Cl^- (trace)	Copper	Cu_2^{++}, Cu^{++}, HCl
Zinc	Zn^{++}, H_2, Cl^- (trace)	Mercury	Hg^{++}, HCl
Cadmium	Cd^{++}, H_2, Cl^- (trace)	Arsenic	H_3AsO_4, HCl
Chromium	(1) Cr^{+++}, Cr^{++}(?), (2) CrO_4^{--}, HCl	Antimony	Sb_2O_4, HCl
Iron	Fe^{+++}, Fe^{++}, H_2, HCl, Cl_2	Bismuth	Bi^{+++}, Cl^-
Cobalt	Co^{++}, H_2, HCl	Silver	AgCl, Ag^+
Nickel	Ni^{++}, H_2, HCl	Platinum	No reaction
Tin	SnO_2, Cl_2, Cl^-	Gold	$AuCl_4^-$ (trace)

into the CrO_4^{--} form. This notable increase in oxidizing strength with temperature can be explained only by some change in the molecular composition of the solution. Although liquid perchloric acid is stable and very hard to reduce, gaseous perchloric acid is very unstable and therefore a powerful oxidizing agent. It is likely that this oxidizing action is inherent in the anhydrous $HClO_4$ molecules.

Reactions with metals.—The reactions of perchloric acid with metals have been summarized in Table 1. From these results it appears that only active metals react at low temperatures, and that they liberate hydrogen with no reduction of the perchlorate group. At high temperatures, the active metals continue the displacement of hydrogen, but with some reduction of the ClO_4^- group; the nobler metals also react, but in their case no hydrogen is evolved, and the perchlorate group is reduced, forming chloride in most cases. Marked passivity is noted in certain cases; e.g., iron, chromium, nickel, etc.

The various reactions of perchloric acid may be simply explained in terms of its ionic and molecular composition, which may be represented by the following equilibrium:

$$H^+ + ClO_4^- \overset{\text{dilution}}{\leftrightarrows} HClO_4.\text{hydrate} \overset{\text{heat}}{\rightleftarrows} HClO_4 + H_2O$$

The liberation of the hydrogen by active metals is characteristic of the H^+ ion. It is interesting to note that this reaction becomes very vigorous when water is added to a hot mixture of acid and aluminum or magnesium.

The dehydration effects are inherent in the anhydrous perchloric acid, and therefore proceed more rapidly with rise in temperature.

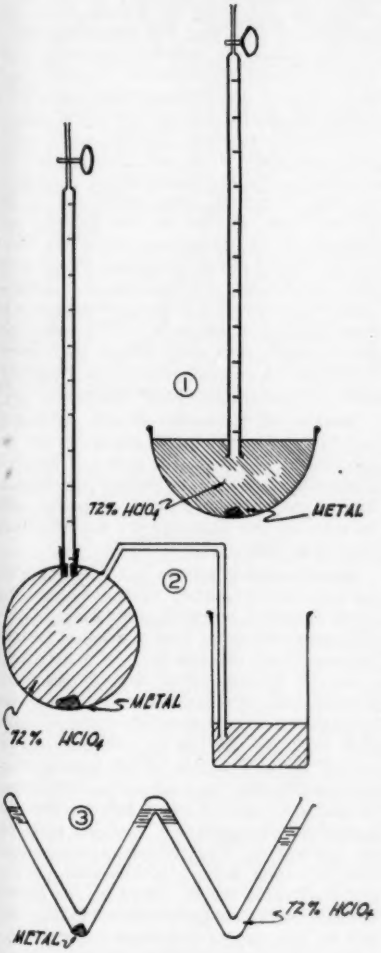
Oxidation is a property of the perchloric acid molecule, particularly the anhydrous $HClO_4$. The ClO_4^- ion is not an oxidizing agent; its neutral solutions will not react with the most vigorous reducing agents. In these reactions perchloric acid shows a definite similarity to nitric acid, e.g., in the passivity effects noted above.

As hydrogen chloride is formed by the reduction of perchloric acid, the solution contains a mixture of hydrochloric and perchloric acid which is analogous in composition to aqua regia. This combination does not have any solvent action on platinum, but its reaction with gold is appreciable. Evidently perchloric acid is not as effective as nitric acid in the oxidation of hydrogen chloride.

Determination of Reaction Products.—The determination of the products formed in perchlorate reactions is a matter of some difficulty. Weighed samples of the metals were completely reacted with an excess of 72 per cent perchloric acid, and the products were analyzed qualitatively and quantitatively. As far as possible, volumetric methods were used for gaseous products, and wet methods for dissolved products. Lack of space prevents extended description. The general procedure may be outlined as follows:

For low-temperature reactions, in which hydrogen is the general product, the apparatus shown in figure 1 was used. For high-temperature work, a closed system is necessary to avoid fuming and possible loss of volatile products. The apparatus in figure 2 was designed for that purpose. In both cases, the apparatus was filled with the acid by suction at the stopcock of the burette. Another type of apparatus was found very useful, especially for high-temperature reactions. It consisted of a tube closed at one end and bent in the shape

of a W (fig. 3). The tube was filled with 72 per cent perchloric acid, and the metallic sample was introduced and maneuvered into the bend next to the closed end. Heat was applied at this point. In this way the gases evolved were retained in the end and the second bend. These gaseous products were then transferred under water to other tubes for analysis.



Apparatus for the analysis of the reaction products of perchloric acid.

The displacement-of-hydrogen proceeded simply in the cases of the more reactive metals—i.e., those occurring above hydrogen in the E. M. F. series. In these cases, an equivalent weight of the metal forms a one-half molar volume of hydrogen. In oxidation reactions, the predominant reduction product was gaseous hydrogen chloride, insoluble in concentrated perchloric acid. The ratio of equivalents of metal consumed to Cl^- ion formed found in all cases to be close to 8:1, showing the "oxidation number" of perchloric acid to be +8. This indicates that the fundamental decomposition of perchloric acid may be represented: $HClO_4 \rightarrow HCl + 4O$. Illustrative equations are:

$$4Ni + HClO_4 + 8H^+ \rightarrow 4Ni^{++} + HCl + 4H_2O$$

$$8Bi + 3HClO_4 + 24H^+ \rightarrow 8Bi^{+++} + 3HCl + 12H_2O$$

In cases of prolonged heating, this ratio was frequently exceeded. The source of this excess chloride was found to be due to a slight decomposition of perchloric acid into hydrogen chloride and oxygen.

The equations obtained by analytical methods are overall equations, and give no information about the concurrent or consequent reactions that may be involved. When concurrent reactions are involved, their relative speeds may vary with conditions, and the overall equations are not definite and are without significance.

Summary.—The very complex equations found in the literature of perchloric acid are a deterrent to the inclusion of this subject in inorganic textbooks.

These discouraging expressions may be eliminated by considering the reactions of perchloric acid to be a summation of the behaviors of the ionic and molecular constituents of the solution. Two or more reactions may take place simultaneously, and their effects are therefore superposed.

In general, perchloric acid shows two modes of reaction: (1) Displacement of hydrogen, without any decomposition of the ClO_4^- group; (2) oxidation, with the reduction of the ClO_4^- group to Cl^- mainly.

SOME COMPARISONS OF FORMAL AND MOLAL OXIDATION POTENTIALS*

G. FREDERICK SMITH

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Introduction.—Molal oxidation potentials are idealized reaction constants. Molal potentials may be evaluated by the use of three independent experimental procedures. The electrochemical method is most direct and results in the use of the least complicated experimental procedure. A second method involves the determination of reaction equilibrium constants. The third procedure is based upon the calculation of potentials using heat of reaction data. Molal potentials determined as a result of all three procedures should give identical results.

Formal oxidation potentials are practical rather than idealized constants. Formal potentials rarely conform in magnitude to molal potentials. The differences between conditions under which molal potentials and formal potentials are determined involve conformity to and deviation from the requirements classed as "standard state." Molal potentials require hydrogen ion concentrations to be calculated to include activity relationships; formal potentials ignore such corrections. Molal potentials include hydrolysis effects, formal potentials do not. Formal solutions from other circumstances do not conform strictly to the prerequisites of conditions of "standard state." The chief discrepancy probably consists in the formation of complex ions the dissociation constant of which is unknown.

It is the purpose of the present discussion to point out some of the wide discrepancies which result from the assumption that reaction constants for oxidation-reduction reactions can be even approximated from the use of molal potential values. The distinction between molal and formal oxidation potential data has been discussed with this point in view by Swift.[1]

"These molal potentials are often of little practical value, and may be misleading, when one attempts to predict from the behavior of oxidizing and reducing agents in the relatively concentrated salt and acid solutions encountered in analytical chemistry . . . These formal potentials could be calculated from the molal potentials (or the reverse) if there were available adequate data for the hydrolysis constants, for the dissociation constants of any complex ions which may be formed, and, finally, for the activity coefficient of the reactants in these relatively concentrated solutions. Since such data are usually inadequate, it is advantageous to have the experimentally measured formal potentials." The situation as it exists was one which may have prompted a Dutch chemist's warning that, 'theory guides, experiment decides."

Section of reactants.—Many oxidizing agents and reducing agents could be selected to illustrate the point of distinction between molal and formal potentials. Two commonly employed reagents will be selected for illustration; namely, ferrous and dichromate ions.

Experimental apparatus.—A potentiometric titration assembly of the usual type consisting of a working cell (2 dry cells), a decade resistance box, a student potentiometer and tapping key, a moderately sensitive galvanometer and a standard Weston cell. The electrode pair used was a platinum wire and a saturated calomel half cell. By the use of a double throw switch the calibration of the galvanometer circuit can be made with reference to the standard Weston cell or the potential of the unknown reaction cell can be measured. The titration apparatus was provided with a mechanical stirrer and calibrated buret. Samples for determination were transferred to the reaction cell by the use of standard pipets. The accuracy claimed for the potentials determined is such that the value is approximate in the third place of decimals.

*Contribution from the Wm. Albert Noyes Laboratory, University of Illinois, Urbana.

[1]Swift "A System of (Chemical) Analysis" Prentice-Hall, 1939 (pages 49–50 and 540).

Descriptive procedure.—A description in detail will be given of a familiar reaction: $Cr_2O_7^{=} + 6Fe^{++} + 14H^{+} \rightarrow 2Cr^{+++} + 6Fe^{+++} + 7H_2O$. The half cell reactions[1] involved are as follows:*

(1) $Cr_2O_7^{=} + 14H^{+} + 6e^{-} == 2\ Cr^{+++} + 7H_2O$ $\quad E^\circ = 1.36$ Volts

(2) $Fe^{+++} + e^{-} == Fe^{++}$ $\quad E^\circ = 0.771$ Volts

Reactants.—$FeCl_3 \cdot 6H_2O$ (app. 0.2 mol.) dissolved in 162.2 ml. of reagent hydrochloric acid (sp. gr. 1.19) and diluted to 2000 ml. making a solution 0.1 formal in ferric ion and formal in hydrochloric acid.

An approxately 0.01666 formal solution of $K_2Cr_2O_7$ in formal hydrochloric acid (0.1 N $Cr_2O_7^{=}$ in F HCl).

Formal hydrochloric acid for dilution purposes made by dilution of 81.1 ml. of reagent hydrochloric acid (sp. gr. 1.19) to 1000 ml.

A 25.00 ml. portion of the ferric chloride solution after passing through a Walden silver reductor was transferred to a 400 ml. beaker and diluted to 250 ml. by addition of formal hydrochloric acid. This solution was then titrated using the 0.1 N $K_2Cr_2O_7$ solution and the resulting potentials were plotted (fig. 1 and table 1).

TABLE 1.—THE POTENTIOMETRIC TITRATION OF FERROUS IONS BY DICHROMATE IONS IN FORMAL HYDROCHLORIC ACID SOLUTION

$Cr_2O_7^{=}$ ml.	E.M.F.[a] Volts	$Cr_2O_7^{=}$ ml.	E.M.F. Volts	$Cr_2O_7^{=}$	E.M.F. Volts
0.00	0.5380	16.00	0.6981	25.85	0.8661
0.50	0.5907	18.00	0.7073	25.90	1.0064
1.00	0.6083	20.00	0.7181	26.00	1.0250
2.00	0.6255	22.00	0.7306	26.10	1.0403
5.00	0.6510	23.00	0.7386	26.30	1.0491
10.00	0.6748	24.00	0.7510	27.00	1.0586
12.00	0.6838	25.00	0.7713	30.00	1.0700
12.50	0.6858	25.50	0.7908	40.00	1.0778
13.00	0.6876	25.60	0.8008	50.00	1.0843
14.00	0.6906	25.70	0.8213	51.80	1.0925

[a]E.M.F. values are corrected to refer to hydrogen electrode as standard.

From the results of Table 1 the formal half cell reactions involved are the following:

(1) $Cr_2O_7^{=} + 14H^{+} + 6e^{-} == 2Cr^{+++} + 7H_2O$ $\quad E^{\circ\prime} = 1.09$ Volts

(2) $Fe^{+++} + e^{-} == Fe^{++}$ $\quad E^{\circ\prime} = 0.69$ Volts

The formal potential for reaction (1) is seen to be at variance with the molal potential to the extent of 20 per cent and for reaction (2) over 10 per cent. It is of interest to calculate the most important reaction constants for the reaction between ferrous and dichromate ions based upon molal potential data as compared to formal potentials. The constants calculated and the general formulation for each constant is as follows:

$$E_e \left(\begin{matrix}\text{equiv.}\\ \text{point}\\ \text{potential}\end{matrix}\right) = \frac{bE^\circ_1 + aE^\circ_2}{a+b}$$

$$-\log K_{(equil.)} = \frac{(E^\circ_1 - E^\circ_2)n}{.059}$$

$$[Red_2] / [Ox_2] = \sqrt[a+b]{\left(\frac{a'b}{ab'}\right)^a K}$$

Then

	Molal	Formal
E_e	1.276 Volts	1.033 Volts
K. equil.	$1.26 \times 10^{+60}$	$1.66 \times 10^{+41}$
$[Red_2] / [Ox_2]$	3.06×10^{-3}	1.65×10^{-4}

TABLE 2.—THE FORMAL POTENTIALS OF THE FERRIC-FERROUS AND DICHROMIC-CHROMIC SYSTEMS IN SULFURIC ACID AND HYDROCHLORIC ACID OF VARIOUS CONCENTRATIONS

Acid Used	$Cr_2O_7^{=} + 14H^{+} + 6e^{-} = 2Cr^{+++} + 7H_2O$ $E^{\circ\prime}$ Values in Volts	E°	$Fe^{+++} + e^{-} = Fe^{++}$ $E^{\circ\prime}$ Values in Volts	E°
1 F HCl	1.09(3)	1.36	0.68(8)	0.771
2 F HCl	1.10(7)		0.67(7)	
3 F HCl	1.19(0)		0.67(1)	
4 F HCl	1.15(0)		0.65(8)	
2 F H_2SO_4	1.10(9)		0.68(8)	
4 F H_2SO_4	1.14(7)		0.68(7)	
6 F H_2SO_4	1.30(0)		0.68(1)	
8 F H_2SO_4	1.34(6)		0.65(8)	

Formal potentials of the ferric-ferrous and dichromic-chromate systems at various concentrations.—The determination of the ferric-ferrous formal potentials at 2, 3, and 4 formal strength of hydrochloric acid were similarly determined (as described in Table 1 and shown graphically in Figure 1). The same procedure

*The molal potentials (E°) are taken from Latimer "Oxidation Potentials," Prentise-Hall, 1938 Formal potentials will be indicated by the symbol $E^{\circ\prime}$.

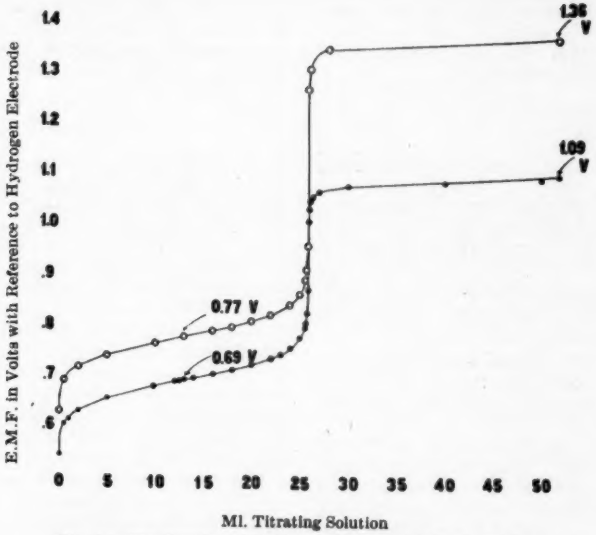

Fig. 1.—The titration of $FeCl_2$ in 1 FHCl solution by $Cr_2O_7^=$ in 1F HCl. (25.00 ml 0.1 N Fe^{++} by 0.1 N $Cr_2O_7^=$)

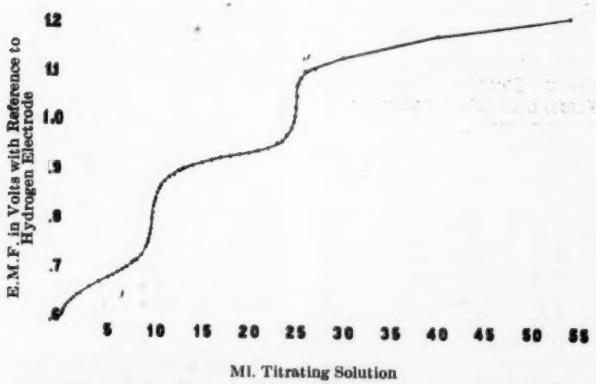

Fig. 2.—The titration of 10.0 ml of Fe^{++} solution plus 15.0 ml of ferrous methyl orthophenanthroline using $Cr_2O_7^=$. Solutions approximately 0.1 N and 4 F H_2SO_4 used throughout. $Fe^{+++} + e^- = Fe^{++}$ potential 0.68 volts, methyl ferriin $+ e^-$ = methyl ferroin 9.06 volts.

gave also the formal potentials for the dichromic-chromic system at the same concentration of acid. In all cases the potentiometric titrational curves were just as smooth and precise and the formal potential values determined could be evaluated with an equal degree of precision. Duplicate titrational curves were obtainable at will and the formal potentials thus determined agreed to within ± 0.01 volt. The same type experiments were carried out with the same systems in sulfuric acid solution except that the ferrous sulfate solutions in the various formal strengths of sulfuric were prepared from ferrous sulfate hexahydrate

and therefore required no reduction before titration. The results appear in Table 2.

Choice of oxidation-reduction indicators for use in the determination of iron by dichromate.—The oxidation-reduction indicator selected for the titration of iron by dichromate has generally been diphenylamine or diphenylamine sulfonic acid. These indicators are of quite low values in potentials which bring about their color change. (0.76 volts and 0.84 volts respectively). For this reason phosphoric acid is always added to lower the oxidation potential of the ferric-ferrous system below the value ordinarily attained in either sulfuric or hydrochloric acid solutions. The use of these indicators is obviously not fully satisfactory. It would be reasoned that because of the presence of the green chromic ion in these titrations, a more vividly colored and more reversible indicator of the ortho-phenanthroline type would be used.

The fact that ferroin indicator is not employed in the determination of iron by dichromate is rather unexplained on the basis of the molal oxidation potential values given for the half cell reaction of the $Cr_2O_7^{=} \rightarrow 2Cr^{+++}$ (1.36 volts) and the ferriin-ferroin system (1.14 volts). The difference between the molal and formal potentials given in Table 2 indicates the failure of conditions to be suitable except in 6 to 8 formal sulfuric acid solution and unsatisfactory conditions at any strength of hydrochloric acid.

Influence of acid concentration on the oxidation potential of indicators of the phenanthroline series.—The indicator ferroin (1-10-orthophenanthroline ferrous sulfate) and substituted phenanthroline indicators such as 5-methyl-1-10-orthophenanthroline ferrous sulfate (methyl ferroin) are subject to very material changes in oxidation potential with changes in hydrogen ion concentration in solutions in which they are employed. These values have been determined in previous work (a report of which is now in press) and are reprinted as given in Table 3.

From the data in Table 3 it is observed that just as with the oxidation of iron by dichromate, wide changes in oxidation potential occur in the indicator system. This requires that both the variations should be taken into consideration when

TABLE 3.—THE FORMAL OXIDATION POTENTIALS OF FERROIN AND METHYL FERROIN INDICATORS

Reactions: Ferriin + $e^- \rightarrow$ Ferroin $E^\circ = 1.16$ Volts
Methyl Ferriin + $e^- \rightarrow$ Methyl Ferroin $E^\circ = 1.10$ Volts

Acid Conc.	Ferriin Ferroin $E^{o'}$ in Volts	Methyl Ferriin-Ferroin $E^{o'}$ in Volts
1 Formal	1.06	1.02
2 Formal	1.03	1.00
3 Formal	1.00	0.96
4 Formal	0.96	0.93
6 Formal	0.89	0.86
8 Formal	0.76	0.70

reaction conditions are to be selected. With this point in view the methyl ferroin indicator would be selected for dichromate titrations of iron because its oxidation potential is lower than that of ferroin. If would be predicted that satisfactory conditions prevail at 4 formal strength of sulfuric acid. A test case potentiometric titration of a mixture of ferrous and methyl ferroin ferrous ions in 4 formal sulfuric acid was titrated using the dichromate ion in 4 formal sulfuric acid solution as oxidant. The values obtained are shown graphically in figure 2. It will be observed that a satisfactory differential titrational procedure results. The use of 2 formal sulfuric acid results in a differential titration the second stage of which reaction is not satisfactory and does not give a vertical break in potential but rather a gradual one. The use of 6 formal sulfuric acid results in a very satisfactory oxidation of the indicator but a somewhat gradual break in potential for the oxidation of the ferrous ion. At 8 formal sulfuric acid concentration there is no sign of a differential oxidation of ferrous and methyl ferroin ferrous ions.

Conclusions.—Formal versus molal oxidation potentials differ over such a wide range under normal variations in titrational environments that special cognizance of this situation is of prime importance. The cases cited in this discussion are typical, not isolated examples. The system of recording formal potentials and molal potentials in the same table of reaction constants as instigated by Swift (loc. cit.) should be extended and emphasis should be placed on the use of these formal potentials in preference to molal potentials as a guide to predicting suitable reaction conditions.

PAPERS IN GEOGRAPHY

FROM THE REPORT OF THE SECTION CHAIRMAN

None of the four papers on the program for the Geography section were presented for publication. They were:

ADAMS, HARRY L., Bloomington, Ill., *The Place of Geography in the Field of Aeronautics.* (With slides.)

BARTON, THOMAS F., Carbondale, Ill., *A Phase of Geography in the Sudbury Area.*

BLANCHARD, O. W., Urbana, Ill., *The Baltic Sea.*

HOLMES, LESLIE A., Illinois State Normal University, Normal, Ill., *Pre-War Truck Movement of Coal from Illinois Mines.*

MR. HARRY L. ADAMS, Bloomington High School, Bloomington, Illinois, was elected chairman of the section for 1943-44.

(Signed) LESLIE A. HOLMES, *Chairman*

PAPERS IN GEOLOGY

FROM THE REPORT OF THE SECTION CHAIRMAN

Thirteen of the fourteen papers on the Geology section program were presented at the meeting and the other one was read by title only. Six of the papers are herein published. Those not presented and those being published elsewhere are as follows:

REYNOLDS, ROBERT R., Illinois Geological Survey, Urbana., *Comparative study of the quartz pebbles in the Lafayette gravel and Caseyville conglomerate of southern Illinois.*

SCHOPF, J. M., Illinois Geological Survey, Urbana, *Shallow coal resources of Wabash County.*

Included in Illinois Geological Survey Report of Investigations No. 93.

CADY, G. H., *The program of oil-well logging of the Illinois Geological Survey.*

PULLEN, M. W., and SIMS, PAUL K., *Use of electric logs in the interpretation of the Pennsylvanian succession in Illinois.*

TAYLOR, E. F., *Structure of the Millersville limestone in Shelby and Cumberland counties, Illinois.*

Illinois Geological Survey Circular No. 95:

HORBERG, LELAND, and EMERY, K. O., *Buried bedrock valleys east of Joliet and their relation to water supply.*

Attendance at the meeting averaged 31.

ALFRED H. BELL, Illinois Geological Survey Urbana, was elected chairman of the section for the year 1943-44.

(Signed) WILLIAM E. POWERS, *Chairman*

KEY BEDS OF THE PENNSYLVANIAN SECTION OF EASTERN VERMILION COUNTY, ILLINOIS, AND VERMILLION, WARREN, AND FOUNTAIN COUNTIES, INDIANA

J. W. ALEXANDER

University of Illinois, Urbana

INTRODUCTION

The area in which the investigations leading to this discussion were carried out includes eastern Vermilion County, Illinois, northern Vermillion County, Indiana, and most of Warren and Fountain counties, Indiana. The strata that crop out in Illinois are included in the Caseyville, Tradewater, and Carbondale groups of Pennsylvanian age, except that the Sparland cyclothem is at the base of the McLeansboro group. In Indiana they are referred to the Mansfield, Bra-

Correlation between outcrops has been difficult at some places because of rapid lateral variations in thickness and lithology of many of the coals, shales, and sandstones. The limestones have proved to be the most important key beds even though some of them are absent or very thin at some places.

No attempt has been made to map this area owing to the lack of topographic base maps over most of the area and the scattered outcrops of bedrock.

Zones that are of value for correlation purposes in this area are numbered on the columnar section and are discussed by number beginning with the highest stratigraphic stratum.

DESCRIPTION OF KEY BEDS

1. The shale above the Danville (No. 7) coal is a thick- to thin-bedded gray shale which at places contains small ironstone concretions. It is 40 to 50 feet thick and persistent enough to be used for correlation purposes. It crops out on Vermilion River west of Danville, Illinois, and on Little Vermilion River west of Georgetown, Illinois.

2. The shale that lies above coal 5a is soft and brownish. It contains many large ironstone concretions and beds of ironstone in the lower part, some of which contain *Leaia tricarinata.* This shale crops out only on Little Vermilion River southeast of Georgetown and is nearly 70 feet thick.

3. The St. David limestone overlies the Grape Creek coal. It is a fine-grained gray limestone that at places becomes mostly shale. It is characterized by *Mesolobus mesolobus var. euampygus* and in the "Double Horseshoe" region contains many *Marginifera muricatina* along bedding-planes. The thickness ranges up to 4 feet.

The limestone is well exposed in numerous outcrops in the south part of Danville, Illinois, and down Vermilion River to sec. 21, a little north of Grape Creek, Illinois. It is not present again until Little Vermilion River is reached in sec. 11, T. 17 N., R. 11 W. It is well exposed at several places in the "Double Horseshoe" region. The discontinuity of the limestone in the Grape Creek area is due to post-St. David erosion during which a channel sand was deposited that cut out everything above the Grape Creek coal. This sand could be the basal member of the Brereton cyclothem, but probably is of Sparland age.

4. Zone 4 contains the marine members of the Double Horseshoe cyclothem. It is composed of two limestones in this area, both of which are thin and discontinuous. The upper bed is a limestone conglomerate which has a light gray limestone matrix and contains black pebbles of varying sizes and roundness. The maximum thickness is 6 inches, and at many places limestone nodules mark its position. This bed resembles the Covel conglomerate and has been correlated with it.

A few inches below is a light gray lithographic slightly septarian limestone. Its maximum thickness is 14 inches along Vermilion River in the SW. ¼ sec. 12, T. 19 N., R. 11 W. This limestone is

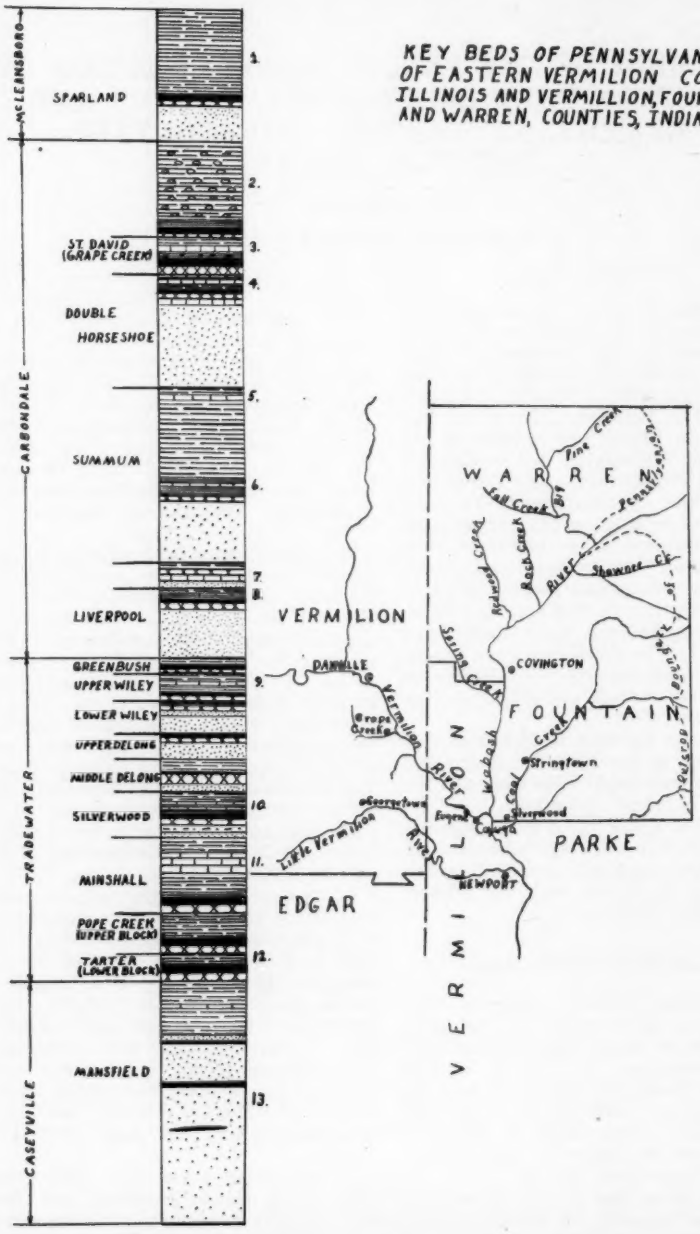
KEY BEDS OF PENNSYLVANIAN OF EASTERN VERMILION COUNTY, ILLINOIS AND VERMILLION, FOUNTAIN, AND WARREN, COUNTIES, INDIANA
MCLEANSBORO
CARBONDALE
TRADEWATER
CASEYVILLE
SPARLAND
1.
2.
ST. DAVID (GRAPE CREEK)
3.
4.
DOUBLE HORSESHOE
5.
SUMMUM
6.
7.
8.
LIVERPOOL
GREENBUSH
9.
UPPER WILEY
LOWER WILEY
UPPER DELONG
MIDDLE DELONG
SILVERWOOD
10.
LITTLE VERMILION
11.
MINSHALL
POPE CREEK (UPPER BLOCK)
TARTER (LOWER BLOCK)
12.
MANSFIELD
13.
VERMILION
DANVILLE
Vermilion River
Grape Creek
Salt Creek
Big Raccoon
Fine Creek
WARREN
Pennsylvania
Raccoon Creek
Redwood Creek
Rock Creek
Shawnee CF
COVINGTON
Wabash
Coal Creek
FOUNTAIN
Stringtown
Sharpwood
PARKE
Indiana
Edgar
Newport
EDGAR
VERMILION

Fig. 1.

also well developed in the "Double Horseshoe" region in the SE. ¼ sec. 19, T. 17 N., R. 10 W. where the Double Horseshoe coal has been stripped and in the SE. ¼ NW. ¼ sec. 32, T. 17 N., R. 10 W. At other places in Danville, as along Little Vermilion River in sec. 11, T. 17 N., R. 11 W. where the No. 5a coal is being stripped, this member becomes nodular.

At two localities nodules of this limestone containing numerous crinoid stems have been seen. These outcrops are near Grape Creek in the NW¼ sec. 27, T. 19 N., R. 11 W. and in the SW. ¼ sec. 14, T. 18 N., R 11 W.

5. Zone 5 is a 4-foot limestone which occupies the position of the Hanover limestone of western Illinois. It is well developed only in the SE. ¼ NW. ¼ sec. 32, T. 17 N., R. 10 W. and in the immediate neighborhood. It is medium-grained, gray, and slightly fossiliferous.

6. Zone 6 is the black shale and black limestone that marks the position of Illinois No. 4 and Indiana IVa coal. The limestone averages 1 foot in thickness. It is a hard carbonaceous limestone that contains plant fossils at Whites' Mill. It commonly lies above about 3 feet of hard sheety black shale, but along Vermilion River a little south of Grape Creek, Illinois, it lies in the middle of about 6 feet of black shale.

This bed is one of the most widespread and easily recognized of all the key beds. It crops out at White's Mill in the NW. ¼ sec. 31, T. 17 N., R. 10 W. on Little Vermilion River and on Vermilion River from a point about two miles west of Eugene, Indiana, upstream nearly to Grape Creek, Illinois. According to the record of a diamond-drill core put down by the Western Brick Company it occurs at a depth of 140 feet in sec. 12, T. 19 N., R. 11 W.

7. In a rudmentary cyclothem below the Summum and above the Liverpool cyclothems occurs a 4-foot fresh-water limestone. It is light gray and fine- to medium-grained. It occurs in two benches both of which contain numerous fresh-water ostrocods. The upper bench is lighter in color, finer grained, and more fossiliferous than the lower.

This limestone is well exposed about two miles west of Eugene, Indiana, in the SW. ¼ sec. 5, T. 17 N., R. 10 W.; the lower bench crops out across Vermilion River in the SE. ¼ NE. ¼ sec. 32, T. 18 N., R. 10 W.

8. Zone 8 is the Oak Grove shale member of the Liverpool cyclothem. It is well exposed in the SW. ¼ NW. ¼ sec. 28, T. 18 N., R. 10 W. and on the road leading west from Eugene, Indiana.

It consists of 5 feet of dark shale with several concretionary bands of fossiliferous limestone. At the base of the shale is a 6-inch dark blue fossiliferous limestone that shows cone-in-cone structure. This limestone is represented by large concretions to the south in Indiana.

9. Zone 9 is the limestone member of the Upper Wiley cyclothem. It is well exposed in a ravine southeast of Newport, Indiana, the SE. ¼ NW. ¼ sec. 36, T. 17 N., R. 9 W., and about 100 feet downstream from the bridge at Eugene, Indiana. It is a black limestone with many white specks due to minute gastropods. It averages about 4 inches in thickness.

10. The name Silverwood is here applied to the cyclothem in which Indiana coal II is developed. This name is used because of the fine development of the marine member of the cyclothem around the town of Silverwood in southeastern Fountain County.

This member is a dark shale, 6 feet thick where it attains its maximum thickness. Near the base occur two thin limestones. The upper is 2 inches thick, dark blue, fossiliferous, and has cone-in-cone structure very well developed. Eight inches below is a 4-inch dark gray limestone. This cyclothem is well exposed on Coal Creek just north of route 234 in the NE. ¼ SW. ¼ sec. 36, T. 18 N., R. 8 W.

11. The Minshall limestone is the most persistent bed of the Pennsylvanian strata of Fountain and Warren counties. It rests at places directly upon the Minshall coal but at others has dark shale above and below. On Redwood and Rock creeks in southern Warren County it is very close to the Mansfield sandstone. In this area there is a thin limestone a few feet below the Minshall limestone.

The Minshall limestone averages about 4 feet in thickness. Its maximum thickness is found on Wabash Mill Creek in sec. 28, T. 18 N., R. 8 W., where it is 10 to 12 feet thick. It is hard, blue, fossiliferous, and sometimes cherty. It shows a well developed set of joints in this area and to the south in Parke County. Along

Redwood Creek in Warren County these joints strike at 18 degrees and 115 degrees from magnetic north. The limestone at this locality carries a silicified fauna that is abundant in gastropods, bryozoa, and many other types of fossils.

12. Zone 12 includes the Upper and Lower Block coals of Indiana which are tentatively correlated with the coals of the Pope Creek and Tarter cyclothems respectively. These two coals are extensively mined to the south around Brazil, Indiana, in northern Clay County. In the area under discussion their development is spotty. One or possibly both reach a thickness of 3 feet near Stringtown, Indiana, in sec. 1, T. 18 N., R. 9 W. North and east of Stringtown the Minshall limestone overlaps the Block coals. It is possible that thin coals locally developed near the top of what is called Mansfield sandstone are of the same age as the Block coals.

13. The basal part of the Pennsylvanian strata in this area is marked by a standstone and shale succession which averages about 150 feet in thickness. The sandstone varies from fine-grained in the upper part to medium-grained near the base. A thin limestone is present in Warren County, near the mouth of Fall Creek where it flows into Big Pine Creek in the NW. ¼ SE. ¼ sec. 22, T. 22 N., R. 8 W. At least three coals are found in the sandstone and may be equivalent to those found at other localities in the Mansfield sandstone. A coal, reported to be 16 inches thick, has been mined on Spring Creek in northern Vermillion County in the SE. ¼ SW. ¼ sec. 10, T. 19 N., R. 9 W. Twenty feet above this coal is a 7-inch bony coal. These coals may be, as stated, the Block coals found farther south. A lens of coal 6 inches thick was seen on Shawnee Creek in northern Fountain County.

POST-WISCONSIN CHRONOLOGY

DON CARROLL

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Accurate computation of the length of time that has elapsed since the final disappearance of the Wisconsin ice-sheet from the Great Lakes region presents a problem that has aroused the active interest of a number of scientists through the years. Recent time may eventually prove to have been but another interglacial stage. Certainly, its span to date is considerably shorter than that of any of the other post-glacial stages that preceded it, and the existence of large continental ice-caps at the present time furnish reason not only for assuming that the glacial period has not yet been concluded, but that the general date of the disappearance of ice from the northern states was more recent than may previously have been believed.

It is the purpose of this paper to point out what the author believes to be inconclusive or inconsistent generalizations in several of the hypotheses that have received prominent attention in past years, with reference to the computation of local post-glacial chronology, and to suggest for consideration a new method of computation that seems to offer more positive data and an exact dating procedure.

Obviously, the length of time since the disappearance of the last ice-sheet is a matter of local variation; and therefore the recent stage for Champaign County, Illinois, for instance, is of somewhat different length than that for the Michigan Peninsula area. Nevertheless, a reasonably exact minimum figure, based on positive evidence rather than on assumption, should be worked out and announced.

Figures regarding the rate of recession of Niagara Falls, no matter how carefully computed, involve too much in the way of personal opinion and interpolation by assumption to fix even a general date for the retreat of the ice from the Lake Ontario basin. Separate investigators have reached separate conclusions, involving a time-spread of from 5,000 to 50,000 years. Considering the undeter-

minable factors involved in the problem this wide margin is not only understandable, but represents the limit of accuracy that is probably attainable. The carving of the gorge has obliterated a preglacial valley that is now occupied by the Niagara River, from the falls to beyond the whirlpool—half the distance to Lake Ontario. Some of the erosion must be credited, therefore, to preglacial stream action. Consider, too, that the limestone cap thins out rapidly to the north, until, at the edge of the escarpment at Lewiston, the exposed section consists almost entirely of shale.

This geologic evidence seems to indicate that the so-called falls must have been originally no more than a series of rapids, cutting quickly through a shale section. Thus, to determine the rate of recession for the past 100 years, based on actual human observation, and then to interpolate that rate on a linear scale corresponding to the total distance from the present falls to the bluff at Lewiston, is to neglect consideration of important factors that were certainly involved to a great extent.

In passing, it should also be pointed out that the falls are known to have varied greatly in width from time to time, and that such variations necessarily affect the rate of recession. The comparative accomplishments of falls recession and side erosion within the gorge, by a swiftly flowing stream, cannot be established, in my opinion. Therefore, any figure on the rate of recession, projected back through thousands of years, can be of little value.

Let us now consider critically the study and interpretation of varves as dating media. The work of De Geer, Mrs. De Geer, Lidèn, Antevs, Sauramo and others have added greatly to our knowledge of sedimentary processes and have supplied valuable data for interpreting the records of the highly complicated history of Pleistocene continental glaciation.

Their work, though, has been largely inspired by the assumption implied in the definition of varves: namely, that they are "annual layers of silt, as deposited in lakes or other bodies of still water." How it can be proved that these layers invariably represent annual accumulations that can be counted and correlated to establish exact chronologies, has not been satisfactorily demonstrated. They are admittedly regarded as "annual by agreement," in the face of ample evidence to the contrary, even in the case of ideal occurrences. In many cases it has been shown that so-called "varves" are but the sedimentary products of individual storms and intervening spells of fair weather.

In this connection, some valuable information might be obtained on the chronological significance of still-water silt layers by taking a core of the silts at the bottom of Lake Decatur, or some other artificial lake of moderate size and known age, receiving sediments from a typical glaciated watershed.

Soil-profile studies, as developed and applied by Leighton, MacClintock, and others, have been used as a yardstick for measuring postglacial intervals, but their value for the reckoning of time is only general and comparative, and dating conclusions based on them cannot be expressed in terms of less than thousands of years.

What, then, can be considered as authoritative, accurate, and incontrovertible evidence of the passage of time, in terms of a definite number of years, during the recent period before modern man appeared and became curious about this subject? It is herein suggested and proposed that the science of dendrochronology can supply the most satisfactory answer to this question. Such workers as Douglas, Stallings, Keen, and others have proved to the satisfaction of botanists that the tree-ring calendar has undisputed validity, and that cross-dating, when done by experts, can and does establish a positive local chronology to the limit of the availability of suitable specimen material.

It is true that tree-ring chronology studies so far carried on have had as their primary objectives either the exact dating of human cultures and occupancies, or the tabulation of climatological or botanical data for past years. The notable success of these studies, in extending the calendar backwards more than 3,000 years in western and southwestern states, leads the writer to believe that similar studies offer the best promise for establishing the time span of the post-Wisconsin stage.

Such studies, it is suggested, would begin with specimens taken from modern trees growing in a locality where a single

species, such as the larch or tamarack, has very evidently been involved in the formation of woody peat beds, such as those of southeastern Wisconsin, and whose descendants flourish today in the same locality. Using the proved methods of study and analysis established by Douglas the investigation could proceed, using cross-dating techniques, with older and older specimens, which can reasonably be expected to be available in any one or many of the woody peat bogs of the Great Lakes region.

Mrs. De Geer attempted, a few years ago, to correlate the varve chronology of Sweden with the tree-ring chronology of the modern California sequoias. The results were inconclusive and led to the conclusion that the tree-ring calendars were unreliable. This conclusion seems unwarranted, in view of the fact that the annual nature of tree rings has been established, and that they do correlate with local modern weather records. In this connection it is worth noting that Douglas, through his tree-ring studies, has shown that the reason for, and time of, the abandonment of the cliff dwellings of the southwest were quite different from the previously accepted theories. They were abandoned by their occupants because of a 21-year drought that began in the year 1276—not because of extermination by enimies, and certainly not in ancient times.

It is by no means held that the proposed peat-log tree-ring studies would yield a complete postglacial chronology for any particular township location, nor is it possible to expect to find critical specimens that record the exact date of the retreat of the ice from a particular spot. The latter possibly cannot be ruled out, as we find numerous specimens of locally-derived wood in the drift itself, and there is no reason for doubting that trees grew on the surface of the ice itself, near the ice margins. They do on the Malaspina glacier in Alaska; and the Pleistocene ice-sheets, according to Thwaites, were drift-mantled near their margins. Furthermore, plant life flourished immediately adjacent to the ice fronts, as Thwaites and others have pointed out.

As for specimen material in the past, however, we can assume that the oldest logs present probably do not date back to the time of the disappearance of the ice. It is held by the writer, though, that the time-hiatus was short and that the originally barren drift was quickly mantled by vegetation, as is the case with strip mine debris—a fair comparison.

The point to be stressed is that the proposed study offers promise for establishing a positive method of fixing the *minimum* length of time, in terms of actual years, since the final retreat of the Wisconsin ice in a typical and restricted locality. It may conceivably solve some related problems dealing with the still-obscure events that took place in the critical areas near the ice front. If logically planned and studiously executed, and if successful, it would yield an exact chronology that would at least check the results of studies of varves, the recession rate of Niagara Falls, and comparative soil profile development. It is further believed by the writer that this check would supply more exact figures than any of the other methods cited, and might well supplant them in favor by substituting fact for supposition. It is even suggested that promising results secured from preliminary investigations of post-Wisconsin tree-ring evidence would lead naturally to the application of this dating technique to the larger problem of Pleistocene chronology in its entirety. At least, this suggestion is hereby placed in the record.

THE PENNSYLVANIAN STRATIGRAPHY OF THE CARLINVILLE, ILLINOIS, QUADRANGLE*

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The northeast corner of the Carlinville quadrangle is at the intersection of 89° 45′ west longitude and 39° 30′ north latitude. This intersection is about one-half mile east of Virden and 20 miles south of Springfield.

Sedimentary rocks of Late Pennsylvanian age crop out in two general regions in the quadrangle. One region is in North Palmyra and South Palmyra townships and extends along Massa Creek and its tributaries nearly the length of the two townships. The other region of outcrops is in the vicinity of Carlinville, near the southern margin of the quadrangle, along Macoupin Creek and its tributaries.

THE CYCLOTHEMS OF THE QUADRANGLE

A number of cyclothems comprise the late Pennsylvanian (McLeansboro) rocks. Typically each cyclothem includes a coal and a marine limestone, but in this quadrangle the coals do not attain a conspicuous thickness, whereas the limestone is represented in all but one cyclothem.

When this quadrangle was mapped geologically in 1930-31 and the manuscript report written, the following cyclothems were recognized.

Cyclothem	*Approximate thickness*
Divide	9 feet
Upper LaSalle (now Upper Livingston)	16 "
Lower LaSalle (now Lower Livingston)	16-17 "
Upper Macoupin	7-12 "
Lower Macoupin	15-23 "
Centralia (Flannigan?)	5 feet
Shoal Creek	35 "
Trivoli (exposed)	34 "

Cyclothem exposures vary so greatly in thickness from place to place in the quadrangle that the above figures are but fair approximations of average thickness. In a recent recapitulation of cyclothem terms,[1] the Collinsville cyclothem occurs between the Trivoli and Shoal Creek cyclothems. At the time of completion of field work in this quadrangle, however, the Collinsville cyclothem had not been recognized in the vicinity.

CARLINVILLE PENNSYLVANIAN STRATIGRAPHY

Trivoli cyclothem.—The full thickness of this cyclothem is probably not exposed in the quadrangle. Neither is the limestone present in the exposures, as it is in each of the other cyclothems. The cyclothem includes No. 8 coal, and in the dark shale above the coal *Lingula carbonaria* Shumard is abundant. Still higher in shale characterized by close-set joint planes is a species of *Aviculopecten* in considerable numbers.

Shoal Creek cyclothem.—This cyclothem is characterized by the absence of coal and by the presence of the most conspicuous limestone in the quadrangle, which has been called both Shoal Creek and Carlinville.[2] In the Carlinville and adjacent quadrangles, the name "Carlinville" is convenient and logical and in his studies in the quadrangle the author used the name "Shoal Creek" for the highest limestone in the quadrangle, mainly be-

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[1] Weller, J. Marvin, Rhythms in Upper Pennsylvanian cyclothems: Trans. Ill. State Acad. Sci., Vol. 35, pp. 145–146, 1942.

[2] Payne, J. N., Structure of Herrin (No. 6) coal bed in Macoupin County, etc., Illinois: Illinois Geol. Survey Cir. 88, p. 5, 1942.
Ekblaw, Sidney, The question of the Shoal Creek and Carlinville limestones: Trans. Ill. State Acad. Sci. Vol. 25, pp. 143–45, 1932.
Worthen, A. H., Geology and Paleontology: Geol. Survey of Ill. Vol. VI, p. 3, 1875.
Weller, Stuart, The Geological Map of Illinois: Illinois Geol. Survey Bull. 1, p. 21, 1906.
Udden, J. A., Notes on the Shoal Creek limestone: Illinois Geol. Survey Bull. 8, pp. 118–119, 125, 1907.

cause an outcrop on an unnamed tributary to the West Fork of Shoal Creek in the outskirts of Litchfield contained numerous imbricated limestone fragments identified as belonging to that limestone.

The characteristic lithologic aspects of the lower limestone (the Shoal Creek) in this and nearby quadrangles are invariable. It ranges from 6 to 8 feet in thickness, and a shale part ıg, commonly about 8 inches thick, separates a lower foot of limestone from that above. Possibly this feature was not so obvious to the early investigators who saw the naturally weathered outcrops, before quarries fully exposed the somewhat massive aspects of the more recently modified faces. It varies from dark gray to almost black in some exposures, and its surface weathering color is a dark yellowish-brown. Its lower member commonly is even darker in color, is finely crystalline, and is frequently marked by widely diverging, more or less individually branching traces or imprints, possibly suggestive of a plant impression or of some crawling organism.

Fossils.—Fusulines have been included in the tentative list of fossils which has been written down for the quadrangle. However, Dunbar and Henbest have not noted them in the Shoal Creek,[7] so to include them in the fossil list is possibly an error. Very common Pennsylvanian fossils have been secured from the limestone, but never in great abundance. The list follows: *Marginifera splendens, Neospirifer cameratus, Composita subtilita, Polypora* sp., *Astartella vera, Schizostoma cateloides, Naticopsis altonensis, N. torta,* and *Phillipsia* sp.

In the exposures in the northwest part of the quadrangle, in shales interbedded with the thinner limestones, species other than those in the above list have been found. Additional micro-organisms probably will be discovered. The following have been recognized: *Ammodiscus incertus,* species of *Tetratraxis* and *Tuberitina, Lingula carbonaria, Trigonoglossa nebracensis, Orbiculoidea missourensis; Euphemus carbonarius, Trepospira illinoisensis, T. sphaerulata, Nuculopsis ventricosa, Sphaerodoma primogenia* cf.

Centralia cyclothem.—The Centralia (Flannigan ?) cyclothem is not fully developed in the quadrangle. The coal and underclay are not represented. Where its limestone is in fullest development there are but few other lamina which seem properly to belong in this cyclothem. A maximum exposure of about 15 feet, in the east outskirts of Carlinville, is mostly sandstone and sandy shale with but little limestone. Some of this sandstone has the aspects of a channel sandstone.

Its limestone, however, is distinguished by the many fossil specimens it carries. Udden[8] has a long list of species. From another outcrop than the one mentioned by Udden, Dr. Needham has made an extensive collection. Because of the brittle resistant nature of the reddish crystalline rock, perfect specimens are rarely obtained. Superficially the *Productid* element in its fauna makes it distinctive, but the rock probably contains many more forms of *Composita* than it does *Productids.* Prominent among the many exceedingly variable forms of *Composita* apparently is *C. trilobata* Dunbar and Condra. Probably *C. elongata* Dunbar and Condra also is present, its condition of preservation such that it frequently gives the impression that it is *Dielasma.*

Other fossils are: *Chonetes granulifer, Linoproductus prattenianus, Juresania nebrascensis, Composita subtilita,* probably other varieties of *Composita, Aviculopecten occidentalis,* and questionable species of *Myalina* ? and *Loxonema* ?. Stratigraphically, this exceedingly fossiliferous limestone is about 17 feet above the Shoal Creek limestone.

Macoupin cyclothem.—Wanless first published the name Macoupin[9] without stating its derivation. From the abundant number of exposures of the limestone with its associated No. 9 coal on Macoupin Creek in the Carlinville quadrangle, the author in his field studies began to dub the limestone the "Macoupin." The cyclical application was first formulated by Dr. Wanless.

Of the several cyclothems in the quadrangle, the Macoupin probably is the best and most typically developed in a single exposure, in a short gully tributary to

[7]Dunbar, C. O., and Henbest, L. G., Pennsylvanian Fusulinidae of Illinois: Illinois Geol. Survey Bull. 67, pp. 13, 16, 1942.
[8]Op. cit., page 120. The "old Walker farm," the "Kirchoff farm," later.
[9]Wanless, H. R., Pennsylvanian section in Western Illinois: Bull. Geol. Soc. America Vol. 47, pp. 811-812, 1931.

Macoupin Creek, just north of Highway 4 and east of the crossing made by that highway over Macoupin Creek, in the NW. ¼ sec. 2, T. 9 N., R. 7 W., and sec. 35, T. 10 N., R. 7 W.

In addition to its display of the best developed coal in the quadrangle, the Macoupin cyclothem carries also a well-developed underclay. In this exposure the underclay is more than 8 feet thick, is structureless and bluish-gray, is calcareous except in the upper 9 or 10 inches, contains small calcareous concretions, and has minute crystals of pyrite and marcasite.

Although satisfactorily developed in this part of the quadrangle, farther north along Macoupin Creek perplexities of stratigraphy occur. The variations always occur below the recognized Macoupin limestone and include one or more thin fossiliferous limestones. One of the limestones has been said to be a "fresh-water" limestone and the other has been assumed to be the Centralia, although its texture, color, and fossil content are different. Possibly rudimentary fragments of other cyclothems than those recognized in this paper are present.

Fossils.—The fauna is marked by the presence of corals, crinoids, and gastropods which are practically absent from the Centralia limestone. J. Marvin Weller has recognized a large fauna in the field exposures and has given his tentative identifications to the author. The list includes: *Lophophyllum profundum, Orbiculoidea missouriensis, Rhombpora lepidodendroides, Marginifera splendens, Chonetes granulifer, Neospirifer cameratus, Ambocoelia planoconvexa, Leda bellistriata, Myalina swallowi, Phanerotrema grayvillensis, Schizostoma catelloides, Pseudorthoceras knoxense, Punctospirifer kentuckyensis,* and various species of *Myalina, Astartella,* and *Metacoceras.*

Upper Macoupin cyclothem.—This cyclothem, a rudimentary cyclothem according to Dr. Weller, is a series of interbedded limestones and shales, possibly only the marine segment of the cyclothem. In its best exposure it aggregates a little less than 8 feet. The two most prominent limestones in the cyclothem range from bluish-gray to purplish in color, both hard and resistant, the lower of the two sparingly fossiliferous. The higher limestone, here called the Upper Macoupin limestone, ranges up to about 4½ feet in thickness, is marked by a *Productid* fauna, and is fossiliferous.

Fossils.—Its fossils include: *Derbya crassa, Pustula pustulosa, Neospirifer cameratus, Linoproductus prattenianus, Punctospirifer kentuckyensis, Ambocoelia planoconvexa,* and *Composita subtilita.*

Lower Livingston cyclothem.—The limestone of the Upper Livingston cyclothem has been called the "LaSalle" limestone by the author in a previously published abstract.[10] In this usage, he was following a correlation suggested by Sidney Ekblaw.[11] Later usage, however, has substituted Livingston, Upper and Lower, for "LaSalle." Independently the author has been impressed by the general correspondence of the LaSalle with the Carlinville quadrangle Livingston, lithologically and faunistically, so that he favored Ekblaw's suggestion.

The conditions of sedimentation for the Livingston cyclothems make it somewhat difficult to discuss the Lower Livingston without constant reference to the Upper Livingston. The most noteworthy fact about the Lower Livingston in this quadrangle is that the marine limestone horizon is a locus of 8 thin limestone strata, ranging from one-half to 2 inches in thickness, and separated by fossiliferous shales up to 9 inches in thickness. Below these strata is a recognizable coal horizon with a little more than 4 feet of clay which may constitute the actual base of the Lower Livingston cyclothem. The limestone strata, as well as the shales, are extremely fossiliferous, containing many specimens and probably several species of *Murchisonia, Aviculopecten, Bellerophon,* and species of possible *Worthenia.* It was from some of these strata, also, that Geis obtained fossil Pedicellariae.[12]

Upper Livingston cyclothem.—The chief stratigraphic interest in this cyclothem, probably, is that it contains the prominent limestone member, the "Shoal Creek" and "LaSalle" of authors. It is the uppermost of the Pennsylvanian

[10]Ball, J. R., Some Pennsylvanian limestones of the Carlinville quadrangle, Illinois: Trans. Ill. Acad. Sci., Vol. 26, page 97, 1934.

[11]*Op. cit.*, page 145.

[12]Geis, H. L., Recent and fossil Pedicellariae: Jour. Paleontology, Vol. 10, pp. 439–441; 448; pls. 60, 61, 1936.

strata in the same gully tributary to Macoupin Creek which displays also all the preceding cyclothems, with the exception of the Trivoli. The limestone is the uppermost in the gully exposures farther east and south in the quadrangle as well, and it has been traced beyond the confines of the quadrangle by Wanless, Sidney Ekblaw, and many others.

In several of the drill records of the quadrangle, the thickness of the limestone ranges up to 12 feet and is about the same in the surface exposures. A relatively thick black platy shale underlies the limestone in many of its outcrops. The shale is resistant to weathering and erosion and is responsible for low waterfall ledges. It is nearly 3 feet thick and is fossiliferous, containing pelecypods, fish spines, and scales, and conodonts.

Fossils.—Fossils weather out readily from the Upper Livingston limestone, and large collections have been taken. *Lophophyllum profundum, L. profundum radicostum,* and large species, either *Lophophyllum* or *Campophyllum* ? are abundant. There are numerous plates and ossicles of crinoids, and many brachiopods and gastropods, including *Chonetes granulifer* and *Chonetes* sp., *Marginifera splendens, M. wabashensis, Wellerella tetrahedra, Dielasma bovidens, Neosporifer cameratus, N. triplicatus, Punctospirifer kentuckyensis, Ambocoelia planoconvexa, Composita subtilita, Platyceras trigonalis, Trepospira sphaerulata, Naticopsis ventricosa,* and species compared with *Wellerella osagensis, Cyrtolites* ? *gillanus, Aclisino condito, A. swallowana,* and recognized *A. stevensana.*

In the thin limestone band horizon of the Lower Livingston cyclothem, *Jonesina arcuata, J. gregaria,* and a species of *Primitia* have been recognized. The list for the Upper Livingston cyclothem is not complete, nor has it been completely checked over, but enough has been cited to show it a very characteristic Pennsylvanian fauna of Illinois.

Divide ? cyclothem.—This probably is but a channel sandstone, so designated by Wanless,[13] as it includes only sandstone and shale. It, or a similar sandstone, cuts through a considerable stratigraphic range if it is the same sandstone which has been observed in several places in this and in quadrangles west and north of the Carlinville. It is observed to have a major thickness of about 10 feet in the quadrangle and, in the field work, was called the "McWain" sandstone because of its several outcrops on the McWain properties along Macoupin Creek.

SUMMARY

Eliminating the "Divide" cyclothem, then, from the list named in this paper, the quadrangle exhibits actually about 100 feet of McLeansboro strata which properly may be included in its cyclothems.

[13] *Op. cit.*, page 812.

A MICROFOSSIL PROFILE OF CERTAIN PENNSYLVANIAN COALS OF OHIO*

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A study of the plant microfossils of coal involves not only academic but also applied or practical investigations. My purpose in studying the coal seams of Ohio has been: (1) to determine the characteristic microfossils, (2) to describe the new species which occur in abundance, and (3) to construct a plant-microfossil profile or spectrum which could be used in correlation of various coal seams and also possibly in determining the vegetational succession, which in turn may give a clue to the plant constituents of certain coal seams.

The Pennsylvanian system in Ohio is divided into four members, the oldest is the Pottsville, the next the Allegheny, then the Conemaugh, and the youngest is the Monongahela. There are approximately twelve important coal seams in Ohio. Of these coals, I have critically studied and recently published[1] my results on the Pittsburgh No. 8 and the Pomeroy No. 8 "a" coals. In addition to these, I have studied the Sharon No. 1 coal and have examined samples of the Middle Kittanning and Freeport coals. Dr. L. R. Wilson of Coe College has been working on the Mercer coal. Thus it is evident that only a good start has been made on this problem.

In the study of the Pittsburgh and Pomeroy coals, a number of microfossils were observed. Of these, two species seemed to be restricted to the Pittsburgh coal. These were *Laevigato-sporites thiessenii* which was the most abundant microfossil of the seam, and *Punctati-sporites grandiverrucosus.*

The Pomeroy coal seam commonly contained many of the microfossils that were found in the Pittsburgh coal but *Endosporites ornatus* was more abundant. Also two new microfossils—*Triquitrites spinosus* and *Punctati-sporites parvipunctatus*—seem to distinguish the Pomeroy seam.

A recent study of the Sharon coal seam has revealed the occurrence of a number of the common microfossils plus the following which appear at present to distinguish this seam: *Triquitrites* sp., possibly *Triquitrites arculatus* Wilson and Coe 1940; *Granulati-sporites* sp., possibly *Triquitrites deltoides* (Wilson and Coe 1940) Schopf, Wilson and Bentall; *Cirratriradites* sp. Raistrick, working on a number of English coal seams, has illustrated and described microfossils similar in appearance to these. His type D-7 is very similar to *Triquitrites* sp., his type D-4 is very similar to *Granulati-sporites* sp., and his type A-3 is somewhat similar to *Cirratriradites* sp.

Dr. Wilson's studies on the Mercer coal have revealed the occurrence of a number of the usual microfossils plus several others which may distinguish this seam.

It may well be that for a complete correlation of all the coals in Ohio, statistical counts of the various species will have to be employed, similar to those used by the paleoecologist working with pollens of Pleistocene and post-Pleistocene peat deposits. However, it seems clear that plant microfossils will prove a valuable aid in correlation work, and that the construction of microfossil profiles is of considerable importance.

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*This study was made while the author was a graduate student in the Botany Department of the University of Cincinnati, Cincinnati, Ohio.

BEDROCK SURFACE AND THICKNESS OF GLACIAL DRIFT IN WILL COUNTY, ILLINOIS[1]

LELAND HORBERG AND A. C. MASON

Illinois Geological Survey, Urbana

Introduction.—In connection with studies concerned with economic and sanitary problems related to groundwater conditions in Will County, maps of the bedrock surface[2] and the average thickness of glacial drift (fig. 1) in the county have been compiled. Relatively detailed control, based on about 3,000 well records, is available for all of the county except the two eastern tiers of townships. Acknowledgments are due Professor D. J. Fisher and Dr. George H. Otto, who in previous years collected a large number of the well records now available.

Present surface.—The thickness of glacial drift represents the difference between elevations of the present ground surface and of the bedrock surface, which was developed largely by preglacial erosion. The major features of the present surface are the Minooka, Rockdale, and Valparaiso morainic ridges, with intervening ground-moraines, which cross the county in a general northwest-southeast direction. Broad valley-trains along the Kankakee, DesPlaines, and DuPage rivers transect and break the continuity of both end moraines and ground-moraines.

The present ground surface slopes in general away from the Valparaiso and other morainic ridges toward the DesPlaines and Kankakee rivers, which join just beyond the west county-line. The highest point in the county is in T. 36 N., R 11 E., and has an elevation of about 797 feet above sea-level; the lowest is along the west line of the county near the junction of the rivers and has an elevation of about 500 feet. This is a relief of approximately 297 feet in about 20 miles, or slightly greater than the relief of the bedrock surface.

Bedrock surface.—Bedrock elevations within the county range from 720 feet above sea-level on the bedrock upland near Monee (sec. 16, T. 34 N., R. 13 E.) to 455 feet where the DesPlaines bedrock valley leaves the county at the west edge of the map (sec. 18, T. 34 N., R. 9 E.). This is a total maximum relief of 265 feet within a distance of 25 miles. Local relief along the sides of major bedrock valleys is sharp. Slopes of 100 feet in a quarter of a mile are present in the vicinity of Joliet.

The bedrock uplands have low to moderate relief, but in general the bedrock valleys appear to be relatively narrow and steep and would be considered youthful. Some of the larger valleys, however, are wide enough to have reached the stage of early maturity.

There is a general parallelism of bedrock valleys and present valleys with respect to their trends and the major drainage systems represented. In detail, however, the relationship breaks down and there are actually but few cases where present streams have inherited valleys from the bedrock surface.

Most of the bedrock valleys of the county are the eastern headwater portions of River Ticona,[3] a large preglacial stream which flowed westward through Grundy, LaSalle, and Putnam counties to the "Big Bend" of Illinois River. Here it joined the north-south trending bedrock valley of the pre-Wisconsin Mississippi, which is occupied by the present Illinois River below that point. The bedrock divide between the southwestward drainage into River Ticona and the northeastward drainage into the basin of Lake Michigan crosses the eastern part of Will County. This divide was cut through near Lemont to form the Chicago Outlet and also it was breached east of Joliet along a buried bedrock valley.

The preglacial valleys of the county probably developed largely by headward erosion along the west margin of the

[1]Published with the permission of the Chief, Illinois Geological Survey.
[2]For map of the bedrock surface near Joliet see Illinois Geol. Survey Circular 95, 1943. An additional map covering a large part of Will County is to be published later by the Illinois Geol. Survey.
[3]Willman, H. B., Preglacial River Ticona, Ill. Acad. Sci. Trans. Vol. 33, pp. 172–175; Illinois Geol. Survey Circular 68, pp. 9–12. 1940.

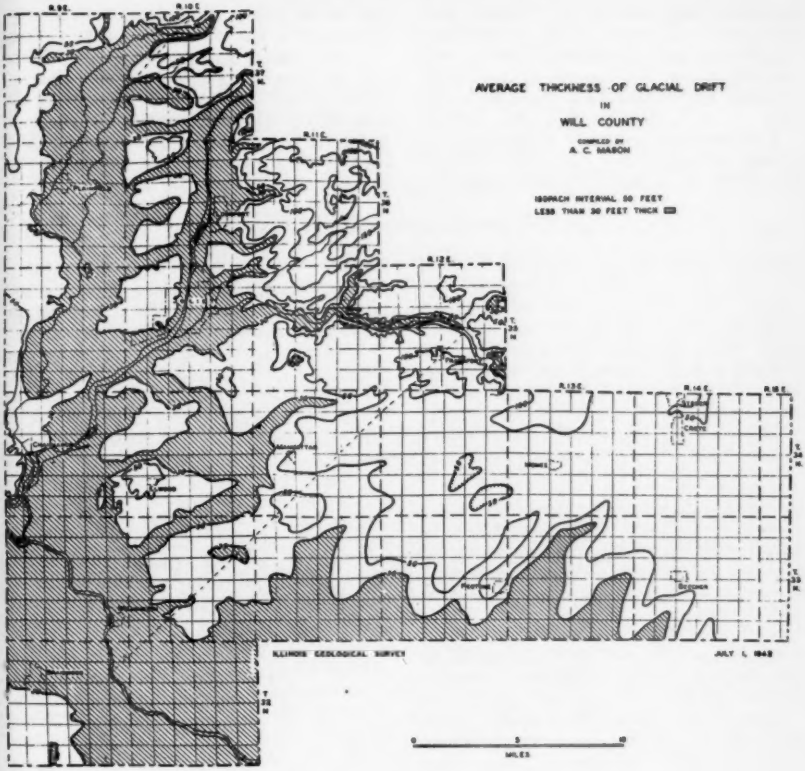

Fig. 1.

Niagaran escarpment which crosses the southwest part of the county. West of the escarpment, bedrock elevations are uniformly lower and reflect a broad lowland eroded on the Maquoketa shale and argillaceous sandstones and shales of the Pennsylvanian system.

Thickness of glacial drift.—Inasmuch as the thickness of the glacial drift (fig. 1) is determined by the difference between elevations of the ground surface and the bedrock surface, the drift is thickest along the undissected portions of the moraines and along buried bedrock valleys. The moraines are of major importance in outlining the three belts of thick drift separated by belts of thin drift, and it is only in the southeast part of T. 36 N., R. 11 E. that bedrock-valley fill is clearly reflected in the thickness map (fig. 1).

The Valparaiso moraine can be traced from the northeast corner of the county (T. 37 N., R. 10 E.) southeastward toward Frankfort and Monee as a belt of thick drift along which the thicknesses range from 50 to over 150 feet. To the west, the Rockdale moraine and associated Manhattan ridge is reflected by a central belt of thick drift extending north-south through R. 10 E. Discontinuous areas along this belt have drift thicknesses of 30 to 50 feet, with occasional small areas of over 50 feet. The Minooka moraine forms the belt of thick drift along the west margin of the county north of Channahon and has drift thicknesses generally between 50 and 100 feet. In the intermorainic areas the drift is

generally less than 30 feet thick. Bedrock crops out almost continuously along DesPlaines and Kankakee rivers, occasionally along DuPage River and other streams, and elsewhere in isolated localities.

The greatest thickness of drift in the county occurs in the east half of T. 36 N., R. 11 E. on the Valparaiso moraine and in the valley of Spring Creek nearby where drift has filled a relatively deep bedrock valley. In approximately 60 per cent of the 844 square miles of area of Will County the drift is more than 30 feet thick, in approximately 35 per cent the drift is more than 50 feet thick, and in only 5 per cent of the county is the thickness more than 100 feet.

INSOLUBLE RESIDUES OF THE LEVIAS AND RENAULT FORMATIONS IN HARDIN COUNTY, ILLINOIS*

F. E. TIPPIE

Illinois State Geological Survey, Urbana

During recent work of the Illinois State Geological Survey in Hardin County, Illinois, it was found desirable to determine zones in the Renault formation and to make more definite separation of the Levias member of the Ste. Geneiveve formation from the overlying Renault formation than has heretofore been possible. Inasmuch as both the Renault and Levias formations are dominantly limestone, the method of study by means of insoluble residues is well suited to the problem. This study is by no means complete, but the data presented in this paper have proved valuable in the work of identifying the stratigraphic positions of limited outcrop sections and diamond-drill cores of these two formations. This in turn assists in the determination of the throw of some normal faults cutting these formations. The general practice in angle-drilling for vein deposits of fluorspar is to drill but a few feet beyond the fault. Rarely is this far enough to penetrate a contact of two formations. Thus by zoning formations one can easily determine the exact throw of the fault.

Samples were obtained both from outcrops and from diamond-drill cores. Two of the sample sets examined were collected from the Cave in Rock fluorspar mining area and the remainder from the Rosiclare area. Samples were taken at every change in lithology unless the lithology was consistent for more than 5 feet. In such cases one sample was taken for every 5 feet. The average sample interval is about 2 feet.

The procedure used was essentially that outlined by L. E. Workman of the Illinois State Geological Survey. A 12-gram sample was dissolved in dilute hydrochloric acid and the coarse and fine residues were separated by decanting. Both fractions were weighed and examined under the microscope. The calculated percentages of insoluble residues were plotted in graphic form (fig. 1) to facilitate the comparison of results from one set of samples with another. The residue graph represents the most complete section available at the present time and is typical of both formations. This graph is based on samples taken from diamond-drill cores of the Rosiclare Lead and Fluorspar Mining Co.—A. C. No. 2 test hole.

The Levias limestone is characterized by relatively little insoluble material, having a maximum of 13 per cent and a minimum of 3 per cent in the sections tested. The average residue content is about 8 per cent. The Levias is subdivided into two zones. The lower zone (A) is characterized by very fine sand grains, showing secondary crystal growth and comprising two to twelve per cent of the rock. These sand grains are probably reworked from the underlying Rosiclare sandstone. Glauconite which also may have been derived from the Rosiclare is present in this zone. The very fine silt and clay fraction is relatively unimportant in this zone and does not exceed 3 per cent of the rock. Zone A is variable in thickness, ranging up to a maximum of 4 feet in the sections studied. The residue graph (fig. 1) exhibits a well developed zone A of Levias.

Zone B of the Levias is characterized by a relatively low average residue content of about seven per cent in the sections studied. The residues are dominantly very fine silt and clay. The coarse fraction, rarely exceeding one per cent of the total rock, is characterized by very fine silt aggregates that are frequently tubular in shape, possibly indicating an organic source. The average thickness of zone B in the sections studied is about 16 feet.

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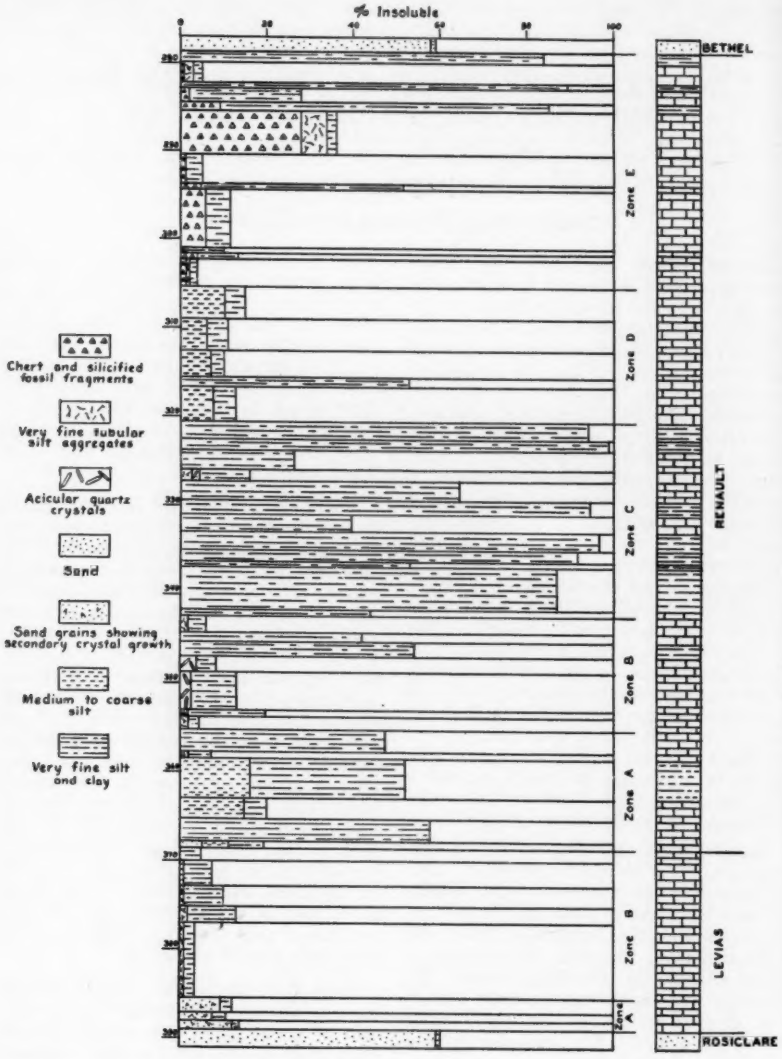

INSOLUBLE RESIDUE GRAPH

ROSICLARE LEAD AND FLUORSPAR MINING CO. - A. C. NO. 2
SEC. 32, T. 12 S., R. 8 E., HARDIN COUNTY

ILLINOIS STATE GEOLOGICAL SURVEY

MAY 1, 1943

Fig. 1.

The contact of the Levias and Renault is characterized by an abrupt change in total residue content, the average content of the Renault being about 40 per cent as compared with the average of 8 per cent in the Levias.

The Renault is subdivided into five zones on the basis of insoluble residues. The total residue of zone A at the base covers a wide range from 10 per cent to as high as 58 per cent, the variation being due to the variable proportion of clay material. The coarse residue is characterized by the presence of medium to coarse silt grains, which comprise 5 to 15 per cent of the total rock. The abundance of silt is the distinguishing characteristic of this zone. The average thickness of the zone is about 14 feet.

Zone B of the Renault is characterized by low total residue content except for a few thin beds of shale. The average residue content is about 9 per cent, dominantly clay. The coarse fraction varies from less than 1 up to 4 per cent of the total rock and consists of fine acicular quartz crystals and very fine tubular silt aggregates similar to those in Zone B of the Levias. A 3-foot shale zone near the top seems to be traceable throughout the area. The average thickness of the zone is about 13 feet.

Zone C of the Renault is a very high residue zone consisting of very finely silty calcareous shales and thin beds of argillaceous limestones. The average residue content is about 75 to 80 per cent. A few of the less argillaceous limestones may have minor quantities of very fine silt aggregates typical of the zone below. The average thickness of this zone is about 20 feet.

Zone D has a relatively low residue content, characterized by an abundance of coarse silt and minor amounts of clay and very fine silt. The coarse silt content ranges from 6 to 10 per cent and the fine fraction from 2 to 5 per cent.

Zone E of the Renault is characterized by chert and silicified fossils, particularly crinoid stems. The total residue content varies from 5 to 27 per cent depending on the per cent of chert present. A few calcareous fossiliferous shale beds tend to increase the average residue content of the zone. The chert is white to faintly bluish. Very fine tubular silt aggregates may be present in considerable quantity, but are not persistent. Frequently silicified brachiopods have been noted. The maximum recorded thickness of this zone is about 35 feet.

In some localities the Bethel sandstone rests directly on zones C and D or on an unusually thin section of zone E. This is indicative of the unconformity recognized at the base of the Bethel sandstone.

Conclusions

It is shown herein that on the basis of insoluble residues the Renault can be readily subdivided into five persistent zones. These zones are applicable to the Illinois fluorspar mining area and may be used to establish stratigraphic position within the Levias and Renault limestones. The unconformity at the top of the Renault formation is very well established by the absence of zones D and E in some localities. The low residue content of the Levias offers sufficient data to separate that limestone from the overlying Renault limestone. The presence of sand grains showing secondary crystal growth in the lower Levias is an adequate criterion to separate the Levias and Rosiclare members of the Ste. Genevieve and to indicate that there was at least a limited amount of reworking of Rosiclare sandstone during the early deposition of the Levias limestone.

Acknowledgments

The author is indebted to the fluorspar operators in Illinois for their cooperation in making available for study the diamond-drill cores obtained in prospecting for fluorspar. Special thanks are extended to Mr. P. L. Richards of the Hillside Fluor Spar Mines, Rosiclare, Illinois, who made it possible to do the laboratory work in an assay office of that company, and to Mr. L. E. Workman of the Illinois State Geological Survey for his helpful criticisms.

PHYSICS SECTION

The Physics Section of the Academy met in joint session with the Illinois State Association of Physics Teachers. A program of formal papers was omitted and the time of the meeting was spent discussing problems of science teaching and teacher training, particularly in the secondary schools. Representatives of sciences and teachers from other sections who were interested also attended and took part.

Dr. E. L. Stover of Charleston, Chairman of the National Research Council's Committee on Wartime Modification of the Curriculum in Biology, presented an outline already agreed on by the biological sciences as appropriate for teachers training for work in the secondary schools. Such a program met with the approval of the physics teachers and others present who went on record as favoring its adoption.

A resolution, which was later adopted by the Academy in general session, was presented, discussed, and approved. Mr. Keeler, of the Illinois State Office of Education, suggested that the Academy Committee provided for in the resolution be instructed to confer with the State Examining Committee and the Committee on Accrediting of High Schools.

It was the sense of the meeting that this committee should work for the adoption of the regulation that a candidate for certification by the State as a science teacher be certified in subject matter field and not merely certified.

Mr. Keeler also pointed out that the Academy might be very helpful to the State authorities in helping to plan a more adequate science curriculum for elementary schools, something which was greatly needed in Illinois.

The following curriculum and resolution are those adopted at the meeting.

REQUIREMENTS FOR LIMITED STATE HIGH SCHOOL CERTIFICATE

		Semester Hours
I. General Education		32
a. Oral and written expression	8	
b. Natural Sciences: Mathematics, Botany, Zoology, (including physiology), Chemistry, Physics.		
c. Social Sciences: History, Government, Sociology, Economics, Geography.	6	
d. Humanities: Modern and Ancient Languages, English Literature, American Literature, Philosophy, Music.		
e. Additional work in any of the above fields	6	
f. Physical Education	3	

*The major and one minor should be in separate areas or subjects selected from those listed in the first paragraph of this section.

*Recommend that all students have more than one minor of 16 semester hours.

II. Education		16
a. Adolescent Growth and Development	2 or 3	
b. Principles and/or Philosophy of Secondary Education, or Professional Ethics	2 or 3	
c. Student Teaching (High School Level)	5	
d. Materials and Methods in the Secondary School, or Methods of Teaching a Particular Secondary School Subject	2 or 3	
e. American Public Education	2 or 3	
f. Electives	2	
III. *One Major (Area of Specialization)		24
IV. *One Minor (Area of Specialization)		16
V. Electives		32
Total		120

TO THE RESOLUTIONS COMMITTEE

Whereas the present national emergency has called attention to the importance of sound education in the sciences and

Whereas sound education in the Sciences will continue to be of fundamental importance following the war and

Whereas such education can be given only by well trained teachers of science

Be it Resolved that, the Illinois Academy of Science, through its executive council, form a representative committee whose responsibility it shall be to formulate plans and policies concerning the preparation and certification of the teachers of the sciences in the schools of Illinois, to the end that, in thoroughness of preparation and ability in teaching, standards be maintained at the very highest possible level.

Be it Further Resolved that, the Committee so formed shall seek to cooperate with the State Department of Education in bringing such plans and policies into actual practice at the earliest possible time.

Respectfully submitted,
O. L. RAILSBACK
Chairman, Physics Section

PAPERS IN SOCIAL SCIENCE AND PSYCHOLOGY AND EDUCATION

FROM THE REPORT OF THE SECTION CHAIRMEN

Sections in Social Science and Psychology and Education held a joint session. A luncheon address was given by Sylvanus M. Duvall, George Williams College, on *Wanted: A West Point for Peace Leadership.*

Six papers were presented at the section meeting, four of which are herein published. The others were:

JAFFE, GRACE M., Barat College, Lake Forest, Illinois, *The Sociological theories of Cournot and Pareto examined in the light of world conditions today.*

SCHERSTEN, A. F., Augustana College, Rock Island, Illinois, *Vice and juvenile delinquency in defense areas in Rock Island.*

ISABEL C. STEWART, MacMurray College, Jacksonville, Illinois, was elected chairman for the section in Psychology and Education for the year 1943-44.

GRACE M. JAFFE, Barat College, Lake Forest, Illinois, was made chairman of the Social Science section for 1943-44.

(Signed) MAX R. GOODSON, *Chairman*
V. D. JOLLEY, *Chairman*

SCIENCE AND THE DAILY PRESS

JAMES S. AYARS
Illinois Natural History Survey, Urbana

Before the New York *Sun*, the first low-priced, large-circulation newspaper in the United States, was founded in 1833, the nineteenth century had felt the impact of a flood of scientific discovery and invention. John Dalton had announced his atomic theory of chemical action that was to help liberate vast hoarded treasures of nature. Oliver Evans had built the first high-pressure steam engine. Only four years before the founding of the *Sun*, Peter Cooper had begun building his terrifyingly swift Tom Thumb engines for the Baltimore and Ohio. Only two years before, Joseph Henry had designed the first electro-magnetic engine.

In the youthful United States, inventions followed scientific discoveries in a giddy whirl, and the large-circulation penny papers, children of invention and the spirit of the lusty age, acted as a catalyst for the creation of still more inventions that followed still more discoveries.

Darwin, Faraday, Kelvin, Mendel, Mendeleef, Pasteur—these are names great among scientists of this zestful age. Some of these names were known to readers of the large circulation papers. Others were not. But if the average reader cared nothing for electro-magnetism of the laboratory, he appreciated the drama of May 24, 1844, when Samuel F. B. Morse sat in the Capitol at Washington and sent impulses along a wire, spelling out "What Hath God Wrought" to Alfred Vail in Baltimore, 40 miles away.

Behind the steam engine, the electric telegraph, and the many other wonders crowding upon the westward sweeping world of the century lay, for the average American news reader, an occult science, a hocus pocus, a mysterious unknown that awed as it excited curiosity. When the *Sun* in 1835 published a series of articles purporting to describe life on the moon, its readers accepted this enormous and cleverly executed hoax as merely another wonder of the modern world. Nothing seemed beyond the ability of man to discover or invent. The pulling power of the hoax in increasing the *Sun's* circulation until it reached the 19,000 mark, then largest in the world, is indicative of the thirst of the nineteenth century newspaper reader for science, or what he mistook for science.

Newspapers alone could not satisfy the avid appetite of the nineteenth century for scientific information. If the news reader could not find in his papers all the science or pseudo-science he required, he turned with eagerness to the world of conjectural science in the novels of Jules Verne. Each year for twenty years following 1862, Hetzel's *Magazin d'Education* published a Jules Verne novel.

Probably most editors of the past century, when they ran science articles in their papers, sincerely hoped for accurate reporting. Dr. J. A. Udden of the University of Texas placed much of the blame for inadequate and inaccurate science reporting as late as 1914 upon an educational system that failed to emphasize science for its prospective reporters.[1] Some editors, however, were less scrupulous and, sensing a circulation builder in the public hunger for science news, resorted to alleged scientific discoveries.

In the course of years, enmity developed between the scientist and the newsman. The newsman is impatient with the scientist's patience. The scientist is impatient only with the newsman's impatience. To the newsman, time is everything. To the scientist, an eon is only another little space of time in the history of the world. Probably the *Sun's* moon hoax did little to bring the scientist and the newsman together at a time when each was becoming convinced that he was the moving force in a world that hourly plunged ahead into new wonders.

After the Twelfth International Geological Congress had met in Toronto in 1913, Dr. Udden made a study of the newspaper coverage of the meeting. Had

[1]Udden, J. A. "Science in Newspapers," Popular Science Monthly 84, p. 483. May, 1914.

the meeting been held in the United States he would presumably have found a similar situation. The six Toronto dailies printed about 55,500 words on the congress. Reports of the proceedings constituted 26 per cent; general information on the congress 19 per cent; social functions 19 per cent; personal notes 12 per cent; interviews 9 per cent; geological excursions, emphasis on the humorous side, 7 per cent; reports of individual papers 6 per cent; editorials 2 per cent; discussion of scientific subjects of popular interest, as the age of the earth, 6 per cent.[2]

"All social functions of the congress were reported with fulness and detail," Dr. Udden commented somewhat sadly.[3]

The date is December 29, 1936. Twenty-three years have passed since the International Geological Congress met in Toronto. The far-flung Scripps-Howard Newspapers have a science editor, a newsman who is so much a scientist that he lectures on general science at Western Reserve University. He is addressing the American Association for the Advancement of Science meeting in Atlantic City. Each day of the meeting, David Dietz tells members of the association, the large metropolitan papers devote one to five columns to the reports of papers presented. "The total amount of space devoted by newspapers of the nation to the meeting is in excess of a thousand columns a day."[4]

In December of the year before Pearl Harbor became a place to remember, the American Association for the Advancement of Science is meeting in Philadelphia. Twenty-seven years have passed since the Toronto congress of geologists. Each of the press associations and several of the large dailies are represented by one or more men trained in science interpretation. If society editors are present, at least their stories do not account for 19 per cent of the coverage.

Science, gleaned from the stodgy verbiage found in individual reports, has become front page stuff in the most important daily in the country.

New Studies Show "Cosmic Phoenix" Operating in Main Sequence Stars

This two-column head is from page 1 of the New York *Times*, December 27, 1940. The story occupies 13 inches on page 1 and 24 inches on page 36. It is by William L. Laurence, a *Times* specialist in science reporting.

In the same issue, the *Times* gives 30 inches on page 36 to a meeting of the State Health and Physical Education Association meeting in Syracuse; 10½ inches to a meeting of boy and girl scientists in New York City; 15 inches to the Archaeological Institute of America meeting in Baltimore. The science news for the day totals 92½ inches, or nearly five columns.

Upper Air is Found To Contain Helium

The *Times* thinks this head and the story below it by Laurence are worthy of 14 inches on the front page, December 29, and 24½ inches on page 22. Other science stories in the same issue are headed "Press Research in Hydrocarbons," from South Hadley, Massachusetts, 13½ inches; "Nuclear Physics studies at Smith," from Northampton, Massachusetts, 10 inches; "Ask Us to Protect Science of World," by Laurence E. Davies, from the American Association for the Advancement of Science meeting in Philadelphia, 37 inches; a short story of 3 inches, also from the Philadelphia meeting; a short story of 4½ inches on the Entomological Society of America, in session in Philadelphia; a story of 15 inches on the American Philological Association, meeting in Baltimore. The day's total of science news is 121½ inches, or over five and one-half columns.

The New York *Times* is not an average or even a typical American newspaper. Nor does the period between Christmas and New Year's Day represent a typical week in the world of science, as most of the scientific meetings are, or were, held at this time of year. But it is significant that a leading newspaper on any two days of the year should devote so much space to scientific news. Still more significant is the treatment of that news. Close to 100 per cent consists of reports of papers presented, written by a skillful interpreter who can read the language of scientists and write the language of breakfast tables and suburban trains.

[2]Udden. *Op. cit.*, p. 484.
[3]Udden. *Op. cit.*, p. 487.
[4]Dietz, David. "Science and the American Press," *Science*, n.s. 85, p. 107.

Other papers across the country carry reports of the Philadelphia meeting, most of them in smaller amounts but not all of them in reduced accuracy.

The improvement in newspaper attitude toward science began with or shortly after the first World War, which was fought with weapons forged by science.

The Boston meeting of the American Association for the Advancement of Science, 1922, "was the first one to be reported in a serious and thorough fashion with a genuine effort to interpret its importance to the public," according to Dietz,[5] who noted in passing that Alva Johnston of the New York *Times* was awarded the Pulitzer prize in journalism for his reporting of this conference.

Founding of the National Association of Science Writers, in 1934, with a membership of 11, represented a sincere effort by the best science newsmen to improve science reporting. The announced purpose was "To foster the dissemination of accurate scientific knowledge by the press of the nation in cooperation with scientific organizations and individual scientists."[6]

The Associated Press has maintained one or more science editors since 1927. In a letter written in 1941, Byron Price, then Executive News Editor of the organization, stated that the Associated Press "has two reporters who devote their entire time to the coverage of science news, particularly to the natural and physical fields. There are several others who might be called specialists in science writing, for although they do not give all their time to it, they are well trained in the handling of science news and are responsible for its coverage in their territories."

Other press associations, the large newspaper chains, and the largest dailies employ writers trained to cover scientific material. Many papers too small to maintain science reporters make liberal use of Science Service, an organization founded by a newsman, E. W. Scripps, to improve the treatment of science by the press.

Although science has failed to bring peace and prosperity to the world, as some persons claimed and some hoped it would do, the public still maintains a notable degree of faith in its potentialities. That the reading public will continue its interest in things scientific there is little doubt. That the public press will continue its attempt to satisfy that interest there is even less doubt.

The World War that began in 1939 is more scientific in character than its predecessor. Will it, like its predecessor, be followed by improvement in science reporting? Scientists hold part of the answer. They should first of all develop a tolerant attitude toward the public with its thirst for science. They should maintain a sympathetic attitude toward the press, attempt to understand some of the difficulties under which news is gathered and distributed, and express themselves so clearly and in such language that they can be misquoted only with difficulty.

Improvement over the past quarter century in the relationship between the newsman and the scientist gives hope for the future. To some extent, each with a contrite heart is willing to admit he has erred in the past. Each now admits, almost freely, that the other is a power in the world. Where mutual forgiveness and mutual admiration prevail, all things are possible, short of absolute perfection.

[5] Dietz. *Op. cit.*, p. 108.
[6] Dietz. *Op. cit.*, p. 109.

THE POVERTY-LINE AND WARTIME SOCIAL POLICY

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It is now fifty years since Charles Booth invented the poverty-line, as a rough and ready yardstick for calculating how many members of a community fall below a minimum standard of adequacy, and why. He brought social science to the service of social policy. Today the guesses of the social scientist can be checked against the guesses of the nutritionist. But the poverty-line remains a rough, though handy, tool; it is not a social micrometer.

Following a long series of British social surveys, Sir William Beveridge set his British poverty-line at not less than £2 a week for a couple and 10s for each child. With adaptations from the Toronto Welfare Council's minima, Leonard Marsh has drawn a broad Canadian poverty-band between $45.00 and $70.00 a month for a couple and $14.50 and $18.00 for the average child. Budgets prepared by our Illinois Public Aid Commission and Department of Public Welfare suggest that the poverty-band at Rockford, Illinois, would lie between $55.00 and $80.00 a month for a couple and $14.50 and $20.00 for the average child. The poverty-line thus interpreted is a broad band, not a slender streak.

This urbanized county with 120,000 inhabitants, of whom 40,000 are now employed—two-thirds of them on "essential" work—contains nine categories of people who live in or near this poverty-band.

First, come substandard wage-earners in intrastate commerce. Illinois has a mandatory minimum wage only for laundresses ($10.00 a week) and beauticians ($16.50). The state legislature has refused to consider a 30¢ minimum. In the absence of a state minimum wage law, our state department of labor is not concerned with collecting any information on substandard wages. The number of intrastate wage-earners at Rockford receiving about $20.00 a week or less is estimated at about 4000. To eliminate these conditions, we need first, a state law compelling the department of labor to find out and publicize the facts; secondly, a state law empowering the department to fix minimum wages and then adjust them to keep pace with changing living costs.

Next come substandard wage-earners in interstate commerce. Under the National Fair Labor Standards Act of 1938, these must receive a statutory minimum of 30¢ an hour unless their trade has a wage order minimum of 40¢. Under a 1941 contract, the trade union minimum in the Rockford furniture industry is 42½¢. The number of interstate wage-earners at Rockford whose earnings are near these minima is estimated at 1,500-2,000. What we lack is national administrative adjustment of these minima to meet rising living costs. Where 40¢ seemed necessary in 1938, 50¢ is needed to-day.

Third come temporarily unemployed wage-earners. Those who did not earn $225 in Illinois during the past twelve months are ineligible for insurance benefits; we therefore have no opportunity to count them. Actual recipients, however, of Unemployment Insurance benefits in Winnebago County have fluctuated between 250 in February and 27 in April 1943. The benefit they receive ranges between $7.00 and $18.00 a week, and may last 16 to 20 weeks. Here we need legislation modifying the $225 rule, which operates against substandard wage-earners; national legislation eliminating state residence qualifications, which penalize labor mobility; legislation lengthening the benefit-period, in readiness for post-war unemployment; legislative raising of the minimum benefit rate, so as indirectly to reinforce the floor beneath wage-levels; and administrative authority to adjust the benefit scale to changes in living costs.

Fourth come social insurance beneficiaries. We seem to have about 800 old-age insurance annuitants and nearly 800 who draw survivors' benefits. These 1600 persons probably represent nearly 1000 units.

Fifth come citizens awarded long-term state assistance because their private means do not suffice to meet a "budget" of minimum needs as estimated by the state department of public welfare. This state assistance budget is more adequate than the local relief budget at Rockford, though not at Chicago; but its food calculations are nearly one year and its clothing calculations nearly two years out-of-date. Awards are made to 1800 elderly citizens enabling many of them to reach this comparatively adequate budget, although a couple awarded the otherwise adequate maximum of $80.00 may have to go on township relief for hospitalization. But aid awarded to 140 families with 350 dependent children is inadequate, because the legislature has limited it to $18.00 in respect of the first child, $12.00 in respect of each subsequent child, and nothing for the guardian. Four-fifths of the ADC families do not reach the state's budget standards, and one quarter of them fall so far short that their ADC has to be supplemented from township poor relief. The legislature ought to provide for the young as adequately as for the old; and the administration ought to keep its budgetary standards up-to-date.

Sixth come recipients of township general relief. Rockford township, with more than five-sixths of the population of the county, now gives home relief to only 250 cases or 500 persons a month, compared with 5,000 cases or 12,500 persons—one-tenth of our population—five years ago. About four-fifths of this improvement is due to increased employment and one-fifth to social security. Easy administrative cooperation between state and township has raised the budget for a couple at home from $45.69 two years ago to $54.57 to-day—an admirable example of flexibility. Unfortunately such a couple is not really given 20 per cent more with which to meet the 20 per cent increase in the cost of living, because the closing of the surplus commodities depot deprives them of an average of $6.00 of supplies a month.

Seventh come a growing number of soldiers' and sailors' dependents. They get the inadequate allowance of $50.00 a month for a wife, $12.00 for the first child, and $10.00 for each subsequent child. They are beginning to apply for ADC. Congress ought to make their allowances adequate.

Eighth come the miscellaneous recipients of small annuities, pensions, and alimony.

Ninth and last come aged and invalid people who to-day depend on the private charity of their families, but in bad times will again become dependent on public charity.

From this prima facie evidence, I estimate that at least one-tenth and perhaps one-fifth of Rockford's inhabitants are living on, near, or below the poverty-line at a time of full employment. I conclude that full employment shows no sign of remedying inadequate living standards, without further legislative and administrative action.

Freedom from want is one of the great ends for which we fight; but the means to this end have yet to be perfected.

GUIDANCE PROBLEMS IN WAR TIME

WENDELL S. DYSINGER

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The tasks of guidance to-day are largely set in the requirements of modern warfare for technical and professional services. Some of the most essential services can be performed only by those with the highest levels of intelligence and training, while many other services require abilities only slightly below these highest levels. Democracy has a strong tradition of equality, and there may be an aristocratic implication in the amendment, equality of opportunity, not equality of ability. Democracy must learn to recognize her leaders, for the decision between Nazism, Communism, and Democracy will rest in large part upon the relative capacities of these forms of government to identify and instruct those who are potential leaders.

Differential abilities among human beings are not hard for Nazi party men to recognize. Since World War I, German leaders have studied the reasons for the defeat of 1918, and much attention has been given to the psychological factors. The collapse of morale on the home front, the extreme fatigue of General Ludendorff, and the panic which developed in the army stimulated research upon related problems. These studies were not accepted with enthusiasm by the army leaders in the early days, but their value was increasingly appreciated. With the coming of the Nazis, such studies were held in higher repute. E. R. Jaensch, a psychologist of prominence, was an early member of the Nazi party, and his influence gave higher status to such work.

The results from these studies are a strange combination of bizarre racial theory and important psychological method. The Jew in psychology as in politics became the scapegoat. The pure Nordic became the ideal type. The rationalization of these prejudices in the name of science is parallel to similar results in anthropology.

There are other more significant results. A developmental record of each youth was preserved. His activities in the youth movement and in school work were recorded, and by the time he reached the age of active army service, a cumulative record of growth was available. Promising young men were identified and additional tests were given. Officer candidates were given long series of tests, and work samples were developed for careful observation of results. Ratings were made by experienced raters, and the total personality was finally appraised as a unit. Decisions remained with military leaders, but the work of those responsible for the identification of leaders is impressive.

When America became involved in the war, the fundamental method for the creation of a large army was the draft and the national lottery. The local draft boards were given quotas which must be filled, and men were delivered to the army with little consideration of the needs for highly skilled and professional abilities in the national effort. College spokesmen emphasized the danger that colleges should be refuges for slackers rather than upon the need for trained leadership.

At the reception centers, tests were administered and interviews were held. An effort was made to place the men in position for maximum service in the war effort, but the extreme pressure under which the work was done and the brief period which could be given to the individual leaves some doubts about the adequacy of these efforts. The appraisal of results can only be made when much more information is at hand.

The schools were not in position to give military men much help. Few schools had cumulative records. The young man might be asked about school experiences, but this is hardly a safe basis for careful personnel work.

School records are often limited to grades and disciplinary procedures. Such records are not complete measures of student growth. Tests are often added.

These instruments are useful when the tests are adequately understood, administered, and interpreted. Many critics of testing procedures are criticizing tests for failing to do what they were never intended to accomplish.

The need of objective records in the crisis has stimulated the use of the cumulative records. Aggressive steps are now being taken to improve these instruments and extend their use. Some of these steps have the approval of our military leaders, and may represent a bridge between the school and the military services.

The outstanding development at the high school age is the High School Victory Corps. This is a voluntary program which unites the high school and the military forces in an effort to develop participation in the war by the future soldier or worker in accordance with his abilities. The publications which have outlined this program are important contributions to education and to military planning.

There are five major units, the Production Service Division, the Community Service Division, the Land Service Division, the Air Service Division, and the Sea Service Division. The high school student may join one of these divisions, or he may hold a general membership.

Guidance services are proposed to aid the student. A pupil inventory has been prepared, a brief but discriminating record. This program includes both the classroom and extracurricular activities, emphasizing physical fitness. How widely the program will be adopted is not yet apparent, although in Illinois the State Director gives an encouraging report.

Guidance at the college level has been confused. The college reserve programs have now largely served their purpose for the older students. These young men have been called to the colors. The chief problems of the future concern the younger men, the physically disabled, the young women, and the high school seniors. The central point of reference in working with these young people in college is service at maximum level within a reasonable time. Attention may be called to certain critical problems in this area.

The teacher shortage is a serious threat to the American school. Teaching should be regarded as highly patriotic service. Acceleration brings many problems to the campus, challenging the traditional sequence of courses and prerequisites. Provision for more rapid progress by the brighter student is now more important than ever. The transition from high school to college has stimulated much discussion. The wisdom of such acceleration probably depends upon the intelligence of the youth, his social maturity, and upon the need of the nation for his services. The training of young people will doubtless represent an increased emphasis upon the technical and a decreased emphasis upon the liberal arts.

The problems of mental hygiene are especially serious for a generation of young people who have never seen a stable world. All adults who live with young people today have an obligation to contribute. Young people need whatever solace the insights of the ages or the hopes of the future have to offer, and they need whatever poise the mature can spare from their own emotional strains.

LIBERAL ARTS EDUCATION IN TIME OF WAR

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There should be an understanding of the difference between General Education and Education in the Liberal Arts. Much of the confused thinking along educational lines in these days is a result of assuming that these are identical.

A General Education is just what the term implies. There is no degree of specialization. All subjects or disciplines are given an equal weight in instruction. At the end, even under ideal conditions, one has but a smattering of this and of that. The student is not fitted for the technical requirements of modern employment nor has he more than the minimum essentials necessary to enable him to see himself in relation to the universe.

An education in the Liberal Arts has well been defined by Erasmus, "The first and principal function of education is to drink in the seeds of piety, to learn and to love classical studies, to be informed concerning the duties of life and for youth to be habituated to courteous manners." This sentence is well worth considerable thought, man's relation to God, to the great minds and souls of the past, service to mankind, and relationship to his fellows. From this it would seem obvious that it is not so much the subject as the spirit of instruction which counts. Liberal subjects, taught in an illiberal fashion, have no claim on the title liberal arts, whereas on the other hand, the most technical of material given in a liberal fashion and related to the whole body of knowledge may embody the whole spirit of a liberal education.

Before leaving this matter of definition I should like to read a sentence from a recent article by Mortimer E. Cooley, Dean Emeritus of the University of Michigan, College of Engineering, and himself a distinguished engineer, "Education is made up of two parts: the first and most important part is teaching man how to live to get the most out of life for himself and to give the most to others; the second part is to give him a professional training enabling him to earn money to carry out the first." Liberal education is concerned with understanding rather than knowledge. One can find many liberal minds full of knowledge, but understanding brings a warm human sympathy encompassing the world.

Now we are in the midst of war. According to the War Manpower Commission any young man, physically qualified, is destined for the armed services. Young women too are urged to prepare themselves for technical tasks to aid in securing the final victory. Must the liberal arts be, or have they already become, a war casualty? If they are already lost or are to become so, can they be revived at the end of the struggle? These questions have been, and are, in the best minds of America. The answers given vary from the blackest pessimism to the brightest optimism. Undoubtedly the answer is somewhere between. Soon the college campuses of the nation will largely be taken over by young men in uniform, training as specialists and officer candidates in the armed forces. The program of studies is prescribed by the War and Navy departments with the design of preparing them for effective use in the services in the shortest possible time. In order to help win the war so we may again live in peace the colleges must cooperate in this training to the best of their abilities.

None the less there are men not wanted by the military, women who are not now needed. Any college failing to carry on a program for these persons, any college failing to keep true to the ideals of the liberal arts, the enrichment of human understanding, will be false to its trust and ideals. The liberal arts may be lost in this case, not at the hands of enemies, but by the neglect of friends. In short, the arts may be lost by default, and this is perhaps the greatest crime we can commit against the younger generation as well as against the liberties of America. If we shut the doors to a liberal education even for a short time the result

may well be like that of the Nazis in Germany in burning the books which gave a continuity to German existence, and helped make possible the imposition of the crazed ideas of a single mind on a generation of German school children. We must defend our liberties and the best means, other than the present necessary battlefields, is to keep the books open and make a liberal education possible.

Most of us have already, in some measure, tried to meet this need. We are engaged in speeded up programs, year 'round college sessions, and other devices to aid in giving as much as possible before our young men go into the service. None of us has been satisfied for no real liberal education can come as a result of hurry and turmoil. One must have leisure to really arrive at understanding. Another phase we have overlooked or disregarded in our haste has been that of the maturity of our students. To arrive at understanding rather than merely absorbing information, a student must mature during the course of his instruction. This is no less a physical than a mental process. We can speed our teaching, we can put in the minutes and hours, but unless we can give young men and women time to mature much of our labor is in vain. No doubt, under the circumstances, half a loaf is better than none, but let us not be deluded into believing we have more than half a loaf. Here is where, in my estimation, the new University of Chicago Plan fails. It is general, not liberal, education; it provides the necessary time but does it produce or take account of the maturity necessary for understanding rather than mere gaining of information?

For the moment most of our energies must be devoted to the winning of the war. At the same time we must be preparing ourselves and our students for the return from violence. It is one of the glories of a liberal education that a man is at home in all ages and under all circumstances. With the war over we must again live in a peaceful world with our former enemies. Together we must try and build a world in which the dignity of man and the right of the individual to a voice in his own future cannot be violated. Only liberal minds can have the breadth of outlook to quickly bury the bitterness of the past and go on to the brighter future. Here America must be the hope of the world. Only on this continent have colleges and universities continued in full vigor. In Europe the light of the humanities has been extinguished by the totalitarian leaders, and education means only propaganda for the "New Order" and technical training for the use of the state.

We must, to win the war, exceed our enemies in technical training, but there is a real danger that we may lose our liberal outlook in so doing. For years there has been pressure for a *practical* education; one which will fit graduates for specific jobs rather than the broad study of the humanistic disciplines. Under pressure of the necessity of the war program this process is well under way. If we are not careful and farsighted we shall be no better than the Nazis. Wendell Willkie in speaking of this subject a short time ago said, "If the humanities or the humanistic temper which they promote are permitted to lapse now we shall have lost the peace before we shall have gained it, and the real victory after the war will be to the way of life, inhuman, tyrannical, mechanical, of those whom we shall outwardly have conquered." This is the gloomy, the pessimistic view of what may or may not happen.

To look at the brighter side of the picture may prove helpful. Many young men, forced to undertake a technical training as part of their contribution to the war effort have been stimulated to question their relations with their fellows and with the universe. One is reminded of the story of the soldier in one of our lonely outposts who discovered a copy of Shakespeare and immediately enrolled in the Armed Forces Institute for a course in that subject. These men who are offering their lives are questioning what it is all about. Most of the answers can come only through a liberal education; literature, philosophy, history, economics, and other disciplines which show the relation of man to the universe and to his fellows. This is well expressed by President Conant of Harvard in a recent article, "For one thing the present fighting generation and the younger boys in school will be tired of hearing even the names of science and technology. When the time for the resumption of normal education returns, a sharp reaction toward studies of a different type, a resurgence of deep interest

in the liberal arts among students themselves, would seem to be inevitable." It is well to remember that President Conant is himself a chemist.

Will we be, and are we, prepared to give this type of education or shall we have gone too far in our enthusiasm for all-out war preparation to return to it?

What I have said so far has been chiefly related to the colleges, but it applies just as much to the high schools. Here too the concern must be with essential and enduring values. In our enthusiasm it is too easy to lose the long view and give our complete attention to the affairs of the moment. The old statement that without vision the people perish is still true. It is our function to keep alive that vision and to provide the means whereby that vision may become an accomplished fact. If we betray our trust, an embittered, cynical, and mechanically minded generation can lose or destroy the vision which was the faith of the founders of this republic in the goodness of man and the essential value of the individual to himself and society.

At this point Christian doctrine and liberal thinking are in accord. We must keep these patterns of thought alive, not only now, in the face of the present emergency, but stand ready to expand them when the present crisis is past. Unless we can do this, there will be no great liberal democratic republic as envisioned by the founders, or as hoped for by their descendants. America will have lost her high destiny while fighting to preserve it. The future is in our hands and we must not prove false to that trust.

From the foregoing statement one might assume that the schools, both secondary and of collegiate rank, are the perfect transmitters of the accumulated wisdom of the past and present. Such is not the case. In this hour of peril to all our institutions it is well for us to take stock of ourselves. We have been burdened with much dead wood in the shape of unreal and antiquated thinking and modes of operation. Now is the opportunity to think through, to reform and refine our procedures, to bring our institutions into line with the light of modern life and thought. If we take advantage of this chance, then, and then only, will we be prepared to render the maximum service to those who have every right to look toward us as custodians of the treasures of the experience of the race. Then, and then only, will young men and young women who have been stimulated to questioning turn to us for the answers. Thus we can fulfill the hopes and expectations of those by whom such institutions were founded and the dreams of those who nourished and helped them grow.

PAPERS IN ZOOLOGY

FROM THE REPORT OF THE SECTION CHAIRMAN

Ten papers were included in the Zoology section program, seven of which were presented before the meeting. One was read by title only. Four of the papers are here published, the others were:

BALDUF, W. V., University of Illinois, Urbana, *A neglected function of biologists.*

CRAWFORD, W. W., Blackburn College, Carlinville, *An unusual case of sexually mature trematode from the body cavity of a diving beetle.*

HOFF, C. C., Quincy College, Quincy, *Some Notes on the Natural History of Reelfoot Lake, Tenn.* (Motion pictures).

REID, W. M., Monmouth College, Monmouth, *The removal of parasites from fowl hosts by means of starvation.*

THOMAS, L. J., University of Illinois, Urbana, *The life cycle of a new Diphyllobothrium tapeworm from the herring gull.*

WRIGHT, GILBERT, Illinois State Museum, Springfield, *Rare and extinct birds in the collection of the Illinois State Museum.*

Attendance at the section meeting was about 26.

CHARLES S. SPOONER, Department of Biology, Eastern Illinois State Teachers College, Charleston, Illinois, was elected chairman for the year 1943-44.

(Signed) HERBERT H. ROSS, *Chairman*

MORTALITY OF THE YELLOW BASS *MORONE INTERRUPTA* AT LAKE CHAUTAUQUA (ILLINOIS)

DONALD F. HANSEN

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Early in May 1942, Merlin N. Nelson and the writer made observations on mortality among fishes at Lake Chautauqua, a shallow 3,200-acre lake on the U. S. Fish and Wildlife Service Refuge at Havana, Illinois. The yellow bass, *Morone interrupta* Gill, was by far the most seriously affected species. According to the statement of Milfred Smith, Refuge Patrolman, the deaths occurred on or about April 23, which was ten days before our visit and approximately one month after the lake had cleared of ice. Our observations were made on fish after they had been washed ashore. Strong south winds during the period of mortality resulted in most of the dead fish being blown to the north shore, where they lay beached in a continuous windrow one to two feet wide. There were very few dead fish on the leeward shore. There was no indication that the fish had undergone putrifaction before they were beached.

On the basis of sample counts made between May 4 and 8 over paced distances of shore line, the total mortality for the lake is estimated to have been in the neighborhood of 75,000 to 125,000 fish of all kinds with an estimated weight of 15,000 and 26,000 pounds or 5 to 8 pounds of dead fish from each acre of water.

By way of comparison, it is estimated from our 1942 creel census that anglers took 2.3 pounds of fish per acre of all species and 0.4 pounds per acre of yellow bass alone.

Among 639 specimens counted in the sample areas, totaling 191 linear feet along the north shore (the windswept shore) 93.0 per cent were yellow bass (*Morone interrupta*), 5.3 per cent were crappies (*Pomoxis annularis* and *P. nigro-maculatus*), and the remaining 1.7 per cent included sheepshead (*Aplodinotus grunniens*), gizzard shad, (*Dorosoma cepedianum*) and bluegill (*Lepomis macrochirus*). Counts on the south shore showed only 20 fish in 175 linear feet, 18 yellow bass and 2 crappies. What may be considered east and west shores of this lake are short and were not examined for dead fish. A single dead buffalo was seen, but not in one of the sampling areas. Certain other species important in this lake, including largemouth bass, yellow perch, and carp were not seen among the dead specimens. There were also many other species of lesser abundance which were not affected.

Sizes affected. — A series of length measurements were taken of the yellow bass found in a short stretch (21½ feet) of the windrow of beached fish. These lengths were tabulated by ½ inch length classes in table 1. In the same table are shown the sizes of the yellow bass taken in hoopnet samples in November, 1941, and in May, 1942; thus, prior to, and after the mortality.

The dead specimens showed nearly the same size distribution as those caught in nets—except that the largest fish seem to have pretty well escaped mortality. The three distributions in Table 1 all show two prominent modes—one at 6½ inches and one at around 8 or 8½ inches. On the basis of ring counts on scales from hoopnet samples obtained in May 1942, I would guess that ages of the dead bass in the shorter size mode were approximately 12 months old and those in the next mode were approximately 24 months old. The age rings in these fish, however, were not too well marked so that this analysis may not be correct.

Cause of death.—Van Oosten (1938) lists ten general causes of fish mortality; two others are described by Powers (1937) and Woodberry (1942). While certain possible causes of the Chautauqua mortality, such as abnormal gas conditions and parasitic infections were not investigated and therefore cannot be

TABLE 1.—SIZE DISTRIBUTION OF YELLOW BASS, INCLUDING BEACHED SPECIMENS AND HOOPNET SPECIMENS

Total Length Classes (inches)	Died in late April, 1942 (beached)	NUMBERS Taken in 1 inch (square mesh) hoopnets	
		November, 1941	May, 1942
5.3–5.7	..	1	1
5.8–6.2	12	5	19
6.3–6.7	24	23	40
6.8–7.2	5	10	9
7.3–7.7	2	..	5
7.8–8.2	11	7	29
8.3–8.7	5	13	12
8.8–9.2	..	..	12
9.3–9.7	..	2	6
9.8–10.2	..	..	1
10.3–10.7	..	..	..
10.8–11.2	..	..	1
Total	59	61	135

ruled out, it may be suggested that death of the yellow bass resulted from the weakening effects of spawning. This cause of death is well known in the Pacific salmon but seems to be an uncommon cause of death among fish in general. Although the Chautauqua mortality occurred approximately at the spawning season of the yellow bass, there is good reason to suppose that some other factor was involved—first, because crappies and bluegills, which ordinarily do not spawn so early, died at the same time as the yellow bass, and second, because death of yellow bass at the spawning season is unusual. Observations on the condition of the gonads in 1943, the year after the mortality, showed conclusively by the presence of ripe eggs and sperm that this (i.e., late April to early May) was the spawning season for yellow bass. The 1943 observations also showed that all sizes of the dead yellow bass were large enough to spawn.

While, as mentioned before, the mortality of the Chautauqua fish had stopped before we arrived at the lake, the yellow bass which we took in hoopnets, May 4-14, were obviously weak, turning belly up soon after they were placed in tubs of water. This sort of weakness was not observed in other species handled at the same time, except that it was noticed in shad, which is unusually sensitive to handling at all times. Weakness of the yellow bass was also observed during the April 27-May 1 hoopnet census of the lake the following year (1943) although no mortality of the species was evident.

The effect on fishing.—Inasmuch as the yellow bass fishing in Lake Chautauqua had been of practically no importance prior to 1942, the mortality had no noticeable effect on the catch in the subsequent months. As a matter of fact, in the four months following the mortality, our creel census showed a very striking improvement in yellow bass fishing over that of both the 1940 and 1941 seasons. In 1940 (data unpublished) four boat liverymen reported the capture of only one yellow bass among about 8,000 fish caught there from May to September.

The complete census at Bridgeman's boat livery, Hansen (1943), showed only 9 yellow bass taken in 1941 (12 months) while at the same livery in 1942, over 1,200 were caught in the first 8 months. With respect to numbers caught, the yellow bass ranked in second place for that 8-month period. They also continued to be taken in large numbers in 1943. It is difficult to see any causal relation between the mortality and improved fishing; a high motrality followed by poorer catches would, however, be commonly expected. Comparison of hoopnet catches before and after the mortality suggests that not over a quarter of the yellow bass died.

Another coincidence connected with this mortality was the fact that yellow

bass, crappies, yellow perch, and especially bluegills were all being caught by anglers at the time of the mortality, and in the week following. The first yellow bass of the season were reported on the census cards on April 21, just two days before the deaths were said to have started.

I am indebted to Charles D. Smith of Liverpool for bringing this mortality to my attention and to Dr. David H. Thompson and Agnes C. Hansen for discussion of the manuscript.

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DISTRIBUTION OF GROUND SQUIRRELS IN ILLINOIS

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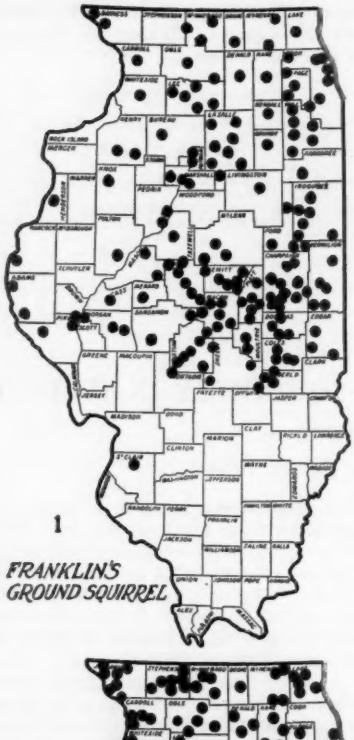
Beginning in 1931 and ending in 1942, the writer recorded the location of every ground squirrel identified during the course of survey work for the Illinois Natural History Survey. Two species occur in Illinois, Franklin's ground squirrel, *Citellus franklinii* (Sabine), and the 13-striped ground squirrel, *Citellus tridecemlineatus* (Mitchill), both species confined to the northern and central portions of the State.

Localities at which these animals were observed are recorded as spots on the accompanying maps (figs. 1 and 2). Town or city names were used as reference points and the ground squirrel recorded as being present near a given town or city if it were observed within five miles of its center as measured by automobile speedometer.

The writer has seen neither species of ground squirrel south of a line connecting Monroe and Crawford counties, although they undoubtedly occur in a number of restricted areas south of this line. Howell, 1928, recorded that a correspondent reported Franklin's ground squirrels present as far south as St. Clair county. The present writer found 13-striped ground squirrels in limited areas as far south as Madison county.

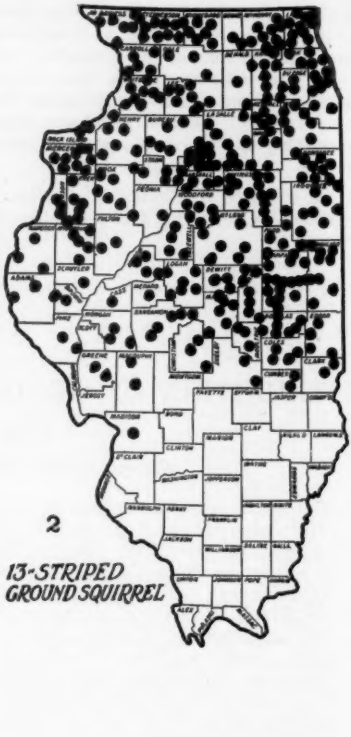
A rough idea of the numerical distribution of ground squirrels may be gained by comparing the number of localities at which they were seen with those at which a more widely distributed animal, the woodchuck, *Marmota monax* (Linnaeus), was seen during the same period and by the same method.

South of the line mentioned above, I have seen no ground squirrels and 39 woodchucks. North of this line I have observed Franklin's ground squirrels at almost as many localities as woodchucks and have seen striped ground squirrels at two or three times as many localities.



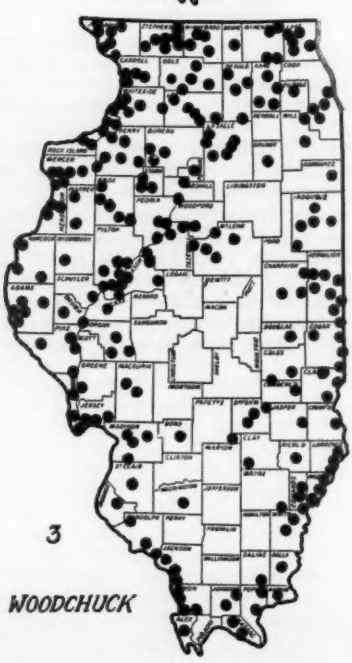
1

FRANKLIN'S GROUND SQUIRREL



2

13-STRIPED GROUND SQUIRREL



3

WOODCHUCK

Maps of Illinois on which are recerded by dots the localities in which the Franklin's ground squirrel, the 13-striped ground squirrel, and the woodchuck were observed, 1931-1942. Comparison of the map showing woodchuck records with the other two maps will give a rough approximation of the numerical distribution of ground squirrels in Illinois.

THE RHOPALOCERA OF PRINCIPIA COLLEGE

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During the past four years the writer has carried on a study of the butterflies occurring in the vicinity of the campus of Principia College. The campus is just seventeen miles northeast of the city limits of St. Louis. It is on some of the highest of the limestone bluffs overlooking the Mississippi River. Ecologically, the hills comprising most of the campus are covered by typical oak-hickory climax forest. A total of seventy-eight species, eighteen subspecies and forms, and one aberration were taken during the study. Five of the seventy-eight species and one of the subspecies are exotic insects not normally to be found here. Of these six butterflies, *Phyciodes gorgone* and *Hemiargus isola* have their normal range more than three hundred miles to the west, *Phoebis sennae marcellina*, *Eurema mexicana*, and *Anthanassa texana* are Texan and Mexican species, and *Strymon m-album* flies in Florida and adjacent states. The presence of southern and southwestern butterflies as far north as central Illinois possibly may be explained by prevailing southwest winds blowing during late summer and fall.

In conducting the study of butterflies at Principia College, the writer has made constant observation of the dates when each species is on the wing. This enabled him to outline the flight periods, number of broods, and abundance of individuals for each species found. The necessary briefness of the present paper eliminates the inclusion of this material, however.

The foodplants of thirty-one species have been determined for this area. Parasites have been reared from six species and have been identified by the United States Bureau of Entomology and Plant Quarantine. An ichneumon-fly, *Epiurus alborictus*, was reared from a larva of the Green-clouded Swallowtail, *Papilio troilus*. This little wasp normally parasitizes the larvae of leaf-rolling moths of the family Tortricidae. Thus, the use of this swallowtail butterfly as a host is noteworthy. The unusual parasitism may be explained by the leaf-folding habit of *P. troilus* larvae. Possibly the female wasp entered the folded leaf of this butterfly larva while searching for the normal host, and deposited an egg within the larva of the swallowtail.

Eight of the ten families of North American butterflies have been taken at Principia College. These are briefly discussed in the remainder of the paper.

Six species of swallowtails, Papilionidae, have been found, all commonly. Host plants have been determined for all six species. Three subspecies have been taken in this family, two of which are merely broods which have received names. The practice of naming broods seems to the writer a useless encumbrance of the already overloaded synonymy of butterflies. The other subspecies is the dimorphic yellow female of the common Tiger Swallowtail. Normal females here are mostly a smoky gray-black, but the subspecies here mentioned applied to the female form whose markings greatly resemble those of the male.

Eleven species of Pieridae have been found. One southwestern species, *Eurema mexicana*, was taken. This has also been taken rarely in Missouri and is a straggler this far north. *Phoebis sennae marcellina* is a geographic race found in the American tropics. A perfect pair has been taken during this study at Principia College: a female on August 25, 1941; a male October 5, 1941.

Our one representative of the Danaidae is *Danaus plexippus*, the Monarch butterfly. As in all other parts of its range, so in Illinois, there is a conspicuous fall migratory flight to the Gulf States and southward. No return flight in spring has been observed, but individuals sometimes are seen in early April. Fresh specimens emerge from the chrysalis in late April. Although he has as yet no verification, the writer believes that numerous eggs are laid in the fall before migration, and that the next year's early brood comes from these eggs. This would

explain the fact that no spring migration of many individuals has even been observed as far south as Illinois.

Only two species of Satyridae have been taken, and one other is doubtless common in mid-summer. The paucity of local species of this family is explained by the fact that the wood nymphs are principally found in the Transition Zone and the Boreal Region.

The family Nymphalidae is represented by nineteen species in the collecting done. Two of these are exotic. *Euphydryas phaeton*, the Baltimore Checker Spot, is a species which breeds in the area of study, but for unexplained reasons it appears only one out of ten or more years. In 1934 numerous larvae were found on the campus of Principia College, and easily reared. That year the species was not rare on the wing. Since then careful searching has revealed no single larva or adult of this species. A similar lapse also preceded this one year of abundance.

Only one species of Libytheidae, or snout butterflies, has been taken. This is *Libythea bachmanii*. It appears irregularly each year, and is attracted in the adult stage to blossoms of both black and honey locust.

Twelve species of Lycaenidae have been taken, and three others probably also occur in the region. Two of the species found must be classed as rare stragglers. In the Bulletin of the Brooklyn Entomological Society (XXXVII, No. 1, pp. 6-8), appeared a paper by the writer discussing the unusual occurrence of *Hemiargus isola*, a tiny blue butterfly rarely ranging east of Kansas. A single slightly worn female of *Strymon m-album*, a Florida hairstreak, was taken on the campus of the college April 18, 1943. The writer knows of only one previous capture of this species in this part of the country, a specimen taken in St. Louis County, Missouri, several years ago.

The last family of butterflies is the Hesperiidae, or skippers. More of these small, heavy-bodied butterflies have been found than any other family, twenty-six species having been taken. Probably about four more will eventually be found. Only one of the skippers caught here is worthy of special note. During the first week of July, 1942, the writer's father, P. S. Remington, Jr., collected a large series of *Problema byssus* at Principia College. This species has previously been known only from the Gulf States, and its occurrence this far north greatly extends its range.

As a result of this four-year study of the butterflies of the vicinity of Principia College, seventy-eight species have been recorded. Five of these are rare stragglers. From twelve to fifteen more species probably breed here. Most of these latter fly during a two-month period of mid-summer when the writer's absence from the campus has necessitated omitting them from the present study. Thus, approximately ninety species of butterflies breed regularly in this small area. Probably less than forty others are to be found in other parts of Illinois. Since about seven hundred species of butterflies are recognized as occurring in North America, more than ten per cent of the North American species are to be found on the campus of Principia College. After careful collecting has been carried on in all main sections of the State, a list of the species found in Illinois may be prepared, and will arouse the same interest as the state lists from California, Kansas, Nebraska, Minnesota, and New York.

LABORATORY FEEDING OF CULICIDAE

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The raising of mosquitoes under caged or laboratory conditions has been extensively practiced with Anopheline mosquitoes for many years, but only a few practical feeding procedures have been derived. Bates (1941), working with *A. maculipennis* var. *atroparvus*, found unfavorable a routine medium of mud, rain water, and bread in water with a high nitrate content. Mud (soil) and sand in routine breeding favored larval growth by furnishing necessary minerals in solution, by serving as a source of organic food, and by acting as an absorbing agent for unfavorable material. A standard medium of calcium sulphate, sodium chloride, and magnesium sulphate in the proportion 5-5-1 parts per thousand made the best medium for early growth when dry bread crumbs were added. Russell and Mohan (1941) used a ten per cent glucose solution for males and rabbit blood for females of *A. stephensi mysorensis*. Gravid females were forced to oviposit by being placed in a test tube which was then knocked gently on the side and the mosquitoes then flung into water in a dish by vigorously swinging the tube. If her legs caught in the water, the mosquito then began to oviposit. Hackett and Bates (1939), while working with *A. maculipennis* in Albania, found the best food for larvae was fine dried bread crumbs. The rearing pans contained a sub-stratum of seived mud and were kept in a heated room in winter with a roof of cellophane and wire screening to admit sunlight. As many as three thousand Anophelines were raised per day with the labor of one man.

Russell and Mohan (1939), in maintaining a colony of *A. stephensi*, removed the eggs from oviposition cages and placed them in paraffined cork rings in a large basin of tap water. Hay infusion and small amounts of a mixture litmus milk and dehydrated blood serum (2-1) were added occasionally and the water was aerated once daily by large pipette. Females were given opportunity to oviposit in bowls of tap water, sea water, and cow-dung water. Eggs were removed in equal numbers from cow-dung and tap water; on only rare occasions were eggs taken from sea water. The rate of growth appeared similar but larvae from cow-dung water seemed best, whereas, larvae from sullage seemed most robust. Development from egg to adult took five to nine days, the gestation period was five to six days. The colony cages were wooden boxes with sides two feet square and a wire screen front with a cloth sleeve entrance. The relative humidity was kept high (seventy per cent) by means of bags of wet sand and pieces of wet cloth suspended in the cages. Glucose (10 per cent) water on cotton wool was kept in each cage and a rabbit was put in every night.

Bertram and Gordon (1939), working with *A. maculipennis* in Liverpool, used a technique similar to that used by Bates. Earth with grass attached, gathered from a small stream bank was brought to the laboratory, broken up by hand and allowed to dry over newspapers and thinned by passing through different wire meshes. Finally, it was stored in five-pound fruit jars which were sterilized at 160°C. for twenty minutes on two successive days. When required for use, nine parts of the prepared earth were mixed with fifty parts of rain water. The mixture was then allowed to settle and the particles floating to the surface were skimed off, since they might inhibit proper development of the larvae. At intervals fresh mud and water were added to another dish of the mixture (2c cm. per larva), to which the larvae were transferred and to which sifted bread crumbs were added daily until the larvae reached the fourth instar. At this point it was found necessary to make a final transfer.

The author, in the winter of 1942-1943 experimented with adult *Culex restuans* and *Theobaldia inornata* to determine their food habits under laboratory

conditions. Since bananas, a known source of food for mosquitoes, were unobtainable, raisins were placed in distilled water in a small glass inkwell and then placed within the mosquito cages. During the first night, December 8, among a series of thirty mosquitoes (T. inornata and C. restuanas) the females (app. 15) engorged 100%, while the males engorged only 80%. On December 15, a similar experiment was run in which raisin juice without the raisins in the solution was fed to *C. restuans*, with the same results. It was thus concluded that the mosquitoes did not necessarily feed but merely drank the extract. On January 4, 1 cc of mallard duck blood mixed wtih 1 cc of an 0.85 per cent physiological saline solution containing 0.05 per cent sodium citrate was offered to thirty female Culicines, but only one engorged. On January 23, ½ cc of frog blood (*Rana clamitans*) plus 1½ cc sodium citrate solution was offered to fifteen females, three of which engorged. On January 26, ½ cc of duck blood pus 1½ cc of saline citrate solution was fed to fifteen mosquitoes (*C. restuans* and *T. inornata*), two were actually seen to feed, and one fell into the solution after engorging and died there. This final experiment was run on the survival mosquitoes from a series of sixty collected in October. Since October, forty-five or 75 per cent had died and the remaining fifteen were fed the blood. All the males had died by December 11. The females had lived well over three months in captivity and if they had been allowed to exist until spring, the mortality might have reached 80 per cent. Of those mosquitoes which do engorge, about three out of fifty die. The highest mortality rate by far occurs among those which will not feed. The above species of mosquitoes are repelled from feeding on duck blood, probably due to its peculiar odor, and could only be induced to feed by diluting the blood to 25 per cent. After feeding the indwell, the mosquito rests from 10 minutes to half an hour before slowly walking away. The mosquitoes used in the above experiments were kept between 60 to 70°F., humidity, 50-60 per cent. They were active from emergence to death; none appeared to be hibernating though several collected on the roof of the cage and moved very little. These mosquitoes are abundant only in fall and spring. *T. inornata* seldom attacks man.

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COLLEGIATE SECTION

Council Members, 1934-1944.

BRIAN NEVILLE, Loyola University, Chicago.
FRANCES HAAS, Rosary College, River Forest.
BETTY O'CONNOR, College of St. Francis, Joliet.
ELIZABETH ANN LIVESAY, University of Illinois, Urbana.

During the year 1941-42 the Academy Council authorized the organization of a Collegiate Section and Dr. T. H. Frison, then President of the Academy, appointed H. R. Wanless, F. M. Fryxell, A. R. Moore, J. W. Neckers, L. W. Miller, R. W. Lefler and Miss D. Richardson as a committee to work out plans for such a section. The Reports of Council Meetings for 1941-1942 (Transactions, vol. 34, no. 4, pp. 259-263) contain brief reports of the work of this committee.

The inaugural meeting of the Collegiate Section was held with the 35th annual meeting of the Academy at the University of Illinois May 8, 1942, with three sectional meetings organized and 37 papers scheduled for presentation. A detailed report of this meeting has been printed (Transactions, vol. 34, no. 4, p. 264-265). The papers submitted for publication were printed in the Transactions (vol. 35, no. 2) but were distributed into appropriate Senior Academy sections as follows: one in Anthropology, one in Botany, and one in Zoology.

With this issue of the Transactions, printing of the submitted Collegiate Section papers as a unit is begun, with the thought that, by lending a sense of individuality, such a procedure will further stimulate interest in the Collegiate Section. Furthermore, the papers submitted, being reports of investigational work done by college seniors, all present a special phase of scientific endeavor that may well be presented as a unit of the Academy's interest.

At the Jacksonville meeting, 16 papers were presented. Six of these are printed in the following pages and the remaining ten are recorded by author and title, as follows:

MARIJANE ANDERSON, Rosary College, River Forest, *Plant Pigments and Plastids.*

ADA JEANNE THOMAS, College of St. Francis, Joliet, *Prevalence of Typhoid Fever in Illinois*—1935-1941.

DOROTHY TATTER, Rosary College, River Forest, *Genetics and Premedics.*

J. A. FRYMIRE, University of Illinois, Urbana, *The Effects of Low Pressures on Colon Activity in the Dog.*

M. VRUNO, Loyola University, Chicago, *The Use of Alizarin Stain for a Microscopic Study of Bone Development in the Chick.*

R. DESALVO, M. KRALICKE, and A. SOWKA, Loyola University, Chicago, *Further Studies on the Cardiac Frequency of the Chick Embryo.*

W. A. TEPPERT, University of Illinois, Urbana, *The Effects of Janus Green B upon the Respiration and Potential of Frogs.*

WILLIAM OESTERLING, University of Illinois, Urbana, *Geological Study of Aerial Photographs in the Uinta Mountains, Utah.*

DOROTHY JOHNSON, University of Illinois, Urbana, *Correlations of the Mississippian in Alaska and Canada.*

EARL COCKRUM, University of Illinois, Urbana, *Stratigraphic Studies on the Mississippian of the Rocky Mountains.*

Attendance at the Collegiate Section was as large as 40 during a part of the time and well over 20 throughout the meeting.

(Signed) H. R. WANLESS, *Coordinator*
Department of Geology,
University of Illinois

ELECTROLYTIC POLISHING OF METALS FOR METALLOGRAPHIC EXAMINATION

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To polish a metal by electrolytic means, the piece is first polished on emery papers, and then the article is made the anode in a cell of a suitable electrolyte and cathode. The proper voltage is applied across the cell, and electrolysis is allowed to proceed until the desired polish is obtained. This method was first tried in 1935, and since that time the process has become increasingly popular, especially in the preparation of metals for examination under the microscope.

Electrolytic polishing has many advantages over the standard method of mechanically polishing metallographic specimens. When properly done, the electrolytic method is much faster than the mechanical method. Also, for many metals, electrolytic polishing gives better results, because, when successfully used, it gives a surface that is completely free of scratches, pits, pulled out inclusions, or flowed metal. Another advantage is that one need not be very experienced in order to use electrolysis for polishing, whereas mechanical polishing can only be done successfully and rapidly by one who has had much experience, and who has become very proficient in that type of work. Because of these many appealing characteristics of electrolytic polishing of metals, the process has been of great interest to metallurgists.

The process also involves certain disadvantages that have retarded its wider adoption. One of the largest difficulties involved is the fact that duplication of results are often difficult to obtain unless a setup can be maintained with unvarying conditions, such as constant specimen size, shape, composition and former treatment. Other variables that exert a considerable influence on the results are the amount of stirring of the electrolyte, the composition of the electrolyte, the distance between the specimen and the cathode, the size of the cathode, and the temperature of the bath. When any one of these conditions is varied, the polish that results will probably not be the same as the polish given by the former conditions. This fact has discouraged many metallographers from trying to use electropolishing. Other disadvantages of the method also exist: (1) Sometimes excessive anodic action takes place around inclusions. (2) For some metals, the most popular electrolyte is the dangerous perchloric acid-acetic anhydride solution. (3) The polished surface sometimes shows undulations.

This paper, however, will be limited to the work which was done on trying to find a way to constantly reproduce results, since this is a large barrier to the wider adaptation of electrolytic polishing to metallographic technique. This work was done by the author, under the direction of Mr. B. G. Ricketts of the metallurgical engineering staff at the University of Illinois. The purpose was to see if polishes can be reproduced, under varying conditions, by using the same anodic potential each time a specimen is polished, since anodic potential is the factor that determines the speed and type of corrosion of the metal.

The procedure used was as follows. Two brass specimens of 70 per cent copper and 30 per cent zinc were cut from ⅝-inch round bar. One specimen was ½ inch long, and the other was ⅛ inch long. Two concentrations of electrolyte were made, one being 540 gms. of orthophosphoric acid per liter of solution, and the other being 430 gms. of acid per liter of solution. Two cathodes of copper sheet were formed, one having an area of 22 sq. cm. and the other having an area of 10 sq. cm. A potentiometer was used to measure the combined voltage of a calomel electrode and the specimen anode half cell, and from that measurement, the potential of the anode was determined while polishing was taking place. A rheostat was used to vary the

bath voltage from zero to any suitable potential difference, to permit the voltage across the bath to be adjusted to give any desired anode potential. The proper reading was then set on the potentiometer, and the rheostat was adjusted until the galvanometer in the potentiometer circuit showed no deflection. This of course indicated that the known potential of the calomel electrode plus the unknown anode potential was equal to the potentiometer setting. By this means, electropolishing was done consistently at the same anode specimen potential.

The first step in the investigation was to get an electropolish on a specimen under certain set conditions. The appearance of the polished surface was then observed closely at both high magnification (400X) and low magnification (40X). The piece was next sanded and repolished in a bath of different acid concentration, but the same anode potential was used, and other conditions were maintained the same, as much as possible. The resulting polish looked apparently the same as the preceding polish, at both high and low magnifications, so this was an indication that electropolishing might be duplicated by controlling the anodic potential of the specimen.

The polishing was then repeated, using different combinations of large or small specimens, dilute or more concentrated electrolytes, large or small cathodes, with or without agitation of the bath, and varied distances between electrodes. (The electrode spacings varied from 2 cm. to 5 cm.) In each trial, the anode potential was kept the same, and as a result, nearly all of the polishes obtained had the same appearance.

In order to compare the current-bath voltage curves with the current-anode potential curves, these observations were made under the different polishing conditions also. An interesting result was that gassing started on the specimen at the same anode potential, regardless of the variables such as solution cencentration, anode size, cathode distance from the anode, etc.

As a result of the observations made during the investigation, three conclusions are warranted:

(1) The reproduction of polished surfaces is consistently possible by controlling the anode potential during electrolytic polishing of metals.

This statement is further justified by the fact that many investigators of electropolishing have reported that the best surfaces are obtained at bath voltages slightly under that at which oxygen is evolved on the specimen; as stated before, the anode potential is always the same at this point, regardless of the many variables listed.

(2) The best anodic potential for polishing a 70 per cent copper-30 per cent zinc brass in orthophosphoric acid solution is in the range of 1.00-1.25 volts, with the higher voltage preferred.

(3) It is probable that each metal and alloy has an anodic potential range in which a specimen is polished with best results.

It would seem desirable, therefore, to determine the most satisfactory potential for each metal. If this is done, then electrolytic polishing will give consistent results, and a wider application in metallographic technique should be possible.

SOME PHYSICAL PROPERTIES OF POWDERED IRON COMPACTS

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Powder metallurgy may provide a quick, economical means of fabricating parts which are difficult and costly to produce by ordinary methods. By compacting the powdered metal under pressure and annealing at a temperature well below the melting point to give the compact added strength, it is possible to produce a finished machine part within fairly close tolerances without once resorting to machining. These parts may be subjected then to "coining" where close tolerances are required. This operation consists of repressing in a die. It gives added strength due to cold work, and improves the surface finish. This powder method is, therefore, particularly advantageous in producing small parts which are difficult and expensive to machine.

The purpose of this experiment is to determine how some of the properties of a hydrogen reduced iron powder will vary with varying conditions of briquetting and annealing, and to determine, if possible, why these changes in properties occur.

The powder used was produced by Metals Disintegrating Company, Inc., and is made from artificially produced iron oxide which is reduced with pure hydrogen. Chemically, it will run about 0.35 per cent manganese, 0.06 per cent carbon, 1.25 per cent oxygen, the balance being substantially iron. This powder was furnished in four particle sizes. The sizes ranged from minus 325-mesh to a minus 100 plus 150-mesh.

One quarter of one per cent of stearic acid was mixed in the powder as a lubricant, and samples weighing approximately 0.85 grams were pressed in a simple two-way compression die at pressures of 26,000, 53,000, and 80,000 pounds per square inch. The compacts thus produced were 0.314 inches in diameter and approximately one-eighth of an inch in length.

In this experiment, the quantity of metal used was measured by weighing; but in industrial applications, the powder is measured by volume. Therefore, it is necessary to know the flow density of the material. The flow density was determined, and was found to increase with increasing particle size. This is due to the greater irregularity of the shape of the fine particles, and to the larger amount of rough surface of the fine powder for a given weight of metal, thus reducing the close contact.

After pressing, the compacts were measured, weighed, and annealed in an electric furnace using a commercial hydrogen atmosphere. This was done at 2000 and 2200 degrees Fahrenheit, time at temperature being one minute, 15 minutes, 45 minutes, and 180 minutes. After cooling in hydrogen, the compacts were measured again, and a Rockwell H hardness was determined for each compact.

For each treatment given the compacts, three samples were used. One from each group of three was selected, mounted, polished, and examined microscopically.

The compressibility of the powders was determined by weighting, measuring the length of the compacts, and computing their lengths to a base weight of 0.8500 grams. Compressibility was found to increase: (1) With increased briquetting pressure; (2) with increased particle size.

After pressing, the compacts have some strength due to cold welding of the particles. This strength is increased with increased briquetting pressure. This increase is due, essentially, to increased area of contact between particles. London states that increased contact is effected by:

(1) The breakdown of "bridging" and the movement of particles into voids of packed masses to reduce porosity thereof;

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(2) the deformation of particles to conform with the internal irregularities of packed configurations of particle boundaries, so that particles may key one into the other; (3) the reduction of interparticle voids by ironing out of surface roughnesses of particles.

Oxide, which is believed to be Fe_3O_4, is present in the powder before annealing due to incomplete reduction of the oxide during the manufacture of the powder. Since large particles require more time for reduction than do small particles, more oxide is contained in the coarse powder. This oxide is distributed randomly throughout the structure, and is not broken up by briquetting at high pressure. Annealing caused the Fe_3O_4 to be reduced with hydrogen, forming water vapor. A new oxide, believed to be FeO, was formed in the voids by reoxidation. This change is hastened by increased temperature. The FeO is then gradually removed at a rate that increases with increase in temperature. Removal of the FeO is also faster in a more dense compact. This is believed to be due to the decreased surface offered for reoxidation.

Annealing of the compacts causes them to shrink. This is accomplished by closing up of the voids due to surface tension, while the metal is in a plastic condition. Generally speaking, shrinkage is increased by the following: (1) Increased time at temperature; (2) increased temperature of annealing; (3) decreased briquetting pressure. Axial shrinkage is consistently greater than radial shrinkage.

A fine grain structure exists in the metal after one minute at annealing temperature. Longer time at temperature caused coalescence of the grains until a limiting grain size was reached. The grain size is reached in less time at the higher temperature, and is essentially the same at 2000 and 2200 degrees Fahrenheit. Decreased particle size of the powder and decreased briquetting pressure tend to decrease the limiting grain size.

The hardness after annealing was generally increased by the following: (1) Increased time at annealing temperature; (2) increased briquetting pressure; (3) increased annealing temperature, except at short times at temperature; (4) increased particle size of the powder. This last was true except for the finest powder, minus 325 mesh, where the effect of shrinkage was enough to increase the density sufficiently to cause it to have the highest hardness of the powders tested. Generally, the hardness values correspond to density values such that increased density was accompanied by a higher hardness.

In industrial applications, mixes of powders are generally used, and are cheaper in price than powders of one particle size, because the manufacturer cannot afford to sell one powder and have no market for the other.

It was desired to run tests using mixes of powders in an effort to find a mix which would give the least possible shrinkage in combination with maximum hardness. This would be accomplished by mixing a coarse powder and a fine one, so that the fine powder would fill the voids between the coarse particles. However, enough time was not available to do this work.

The most desirable properties, low shrinkage and high hardness, are obtainable using high briquetting pressure, but ordinarily, die wear will limit industrial applications to about 600,000 pounds per square inch. Low shrinkage is desired, because more variation is inherent where shrinkage is high, and tolerances would be more difficult to meet. Allowable shrinkage is limited by the design of the part to be made, the tolerances to be met, and whether the part is to be "coined" after sintering.

It is necessary, then, in commercial practice to select the briquetting pressure, and annealing time and temperature, which would give the best balance between desirable and undesirable properties for those particular parts which are to be manufactured.

MINERAL CONTENT IN FRUIT JUICES

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According to Sherman in "Chemistry of Food Nutrition," mineral or inorganic elements are those elements which are found to remain either wholly or largely in the ash of food materials when the latter are burned in the air.[1]

The mineral elements in the body that are of great importance are calcium, iron and phosphorus.

The general functions of the mineral elements in the body are threefold:

(1) As constituents of the bones and teeth, giving rigidity and relative permanence to the skeletal tissues, as the elements calcium and phosphorus.

(2) As essential elements of the organic compounds which are the chief solid constituents of the soft tissues (muscles, blood cells). Both iron and phosphorus may come under this function.

(2) As soluble salts (electrolytes) held in solution in the fluids of the body, giving these fluids their characteristic influence upon the elasticity and irritability of muscle and nerve, supplying the material for the acidity or alkalinity of the digestive juices and other secretions, and yet maintaining the approximate neutrality of the body's fluids as well as their osmotic pressure and solvent power.[1]

Calcium constitutes a larger proportion of the body weight than does any other of the "inorganic" elements. The "ordinary mixed diet" of Americans and Europeans, at least among dwellers in cities and towns, is probably more deficient in calcium than any other chemical element.

Although the amount of iron contained in the body is small—hardly one tenth of an ounce in the entire body of a full grown person or about 0.004 per cent—its functions are of the highest importance. Iron stands in the closest possible relation to the fundamental processes of nutrition. Although iron occurs in meats (the muscle part) eggs, milk, grain products, vegetables and fruits, we will stress its presence in fruit juices.

Phosphates are utilized in maintaining the acid-base balance of the blood and in the synthesis of important cell constituents.

It has been found in the experiments of Sherman and Howley that a child needs for optimal growth and development about one and one half times as much phosphorus as is needed by a full grown man for maintenance.

In our problem, we determined by various methods, the nutritive content of fruit juices in regard to the amount of calcium, iron, and phosphorus they contained. The fruit juices tested were tomato, orange, grapefruit, and pineapple. The results have been checked with "Chemistry of Food and Nutrition" by Sherman and also data supplied by the United States Department of Agriculture, Bureau of Home Economics.

Mineral Content of Fruit Juices
(per cent)

JUICES	Ca	P	Fe
Tomato	0.006	0.015	.....
Orange	0.029	0.016	0.00024
Grapefruit	0.015	0.014	0.00023
Pineapple	0.015	0.021	0.00025

Calcium was determined gravitimetrically by the oxalate method, phosphorus, volumetrically by the molybdate method, and iron was determined colorimetrically.

Even though the percentages of iron are comparatively small, when we remember the small amount or iron in the body (tenth of an ounce) we can see that the appreciable amount of iron in juices would be a big help in supplying the iron content for the body.

Present day nutrition, it has been said, offers an extra ten years to the life of anyone who lives under its guidance.[2] Since the war and food rationing has begun, constant efforts have been made to maintain the proper diet containing the necessary vitamins and minerals.

Food fads and follies have been exposed. Journals have been trying to tell

the story of good nutrition from every possible point of view yet regardless of every effort that can be made, there are great numbers of Americans who still eat much more from the point of view of appetite than of foods necessary to health and growth.

To summarize briefly this report on the nutritive content of fruit juices, we conclude that both vitamin C and the minerals calcium, iron and phosphorus are present in tomato, orange, pineapple and grapefruit juices.

We know now that Vitamin C not only protects us from scurvy but has important functions also in normal nutrition and in maintenance of a high level of positive health. The minerals may also be included under the phrase—"necessary for normal nutrition."

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VITAMIN C CONTENT IN FRUIT JUICES

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This discussion will cover the nutritive value of some common fruit juices from the standpoint of vitamin and mineral content.

Fruit juices are defined as "the fluid content of fruit."[1]

Vitamins are "any of a group of constituents of most foods in their natural state of which very small quantities are essential for the normal nutrition of animals and possibly of plants. Six distinct vitamins are known."[1]

A recognition of the antiscorbutic property of some foods led to the isolation and later synthesis of vitamin C. It came to be called the antiscorbutic vitamin, water-soluble C, and most commonly vitamin C.

From all that is given in literature as a result of extensive research, vitamin C not only protects from scurvy but has important functions also in normal nutrition and in the maintenance of a high level of positive health.

If vitamin C is so important for normal nutrition the questions naturally follow: What is vitamin C? How do we know we have it? Where can it be obtained? Is vitamin C destructible and how much is required for an average person?

Vitamin C is a vitamin called ascorbic acid.

Vitamin C can be detected by reduction-oxidation reactions and its detection can be made iodimetrically due to its ease of oxidation. Because of the unsaturation of ascorbic acid it is easly oxidized and therefore the vitamin C value of food, especially fruit juices, deteriorates upon standing (oxidation of air).

The best sources for this vitamin are asparagus, oranges, lemons, grapefruit, raw cabbage, tomatoes, spinach and potatoes.[2]

From a series of studies the National Nutrition Conference set 75 mg. daily as the requirement.[3]

The following are a result of our investigation:

Vitamin C Content in mg./100 ml.

Juices	Fresh	A.R.°	Canned
Grapefruit	56	47	
Orange	72	65	33
Tomato		20	30
Pineapple	50	35	10

° After Refrigeration

These values have been checked with with the publication issued by the United States Department of Agriculture. Our results are higher, perhaps due to the fact that vitamin C is regenerated by reducing agents, such as hydrogen sulfide, which is usually present in the laboratory.

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MYOPIA—ACQUIRED AND HEREDITARY

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If the parallel rays of light come to an exact focus on the retina, the refractive index is that of a normal eye. But if the rays focus in front of the retina, we have a condition known as near-sightedness or myopia. Therefore, we can say that myopia is a name applied to the refraction of an eye in which there is a focus of parallel rays in front of the retina.

Types.—Myopia is divided into two types, axial and refractive. Axial myopia is due to the elongation of the posterior segment causing the retina to be pushed back, thus the converging rays focus in front of the retina. Accommodation of the eye for near and distant vision is made possible by virtue of the elastic nature of the lens under the control of the ciliary muscle and the suspensory ligament. The lens must change shape so as to converge all rays of light exactly on the retina. Thus, when the ciliary muscle contracts, it causes the ciliary process to approach the lens and the suspensory ligament to relax, so the lens rounds up, as is necessary for near vision; conversely, when accommodating the eye for distant vision, the ciliary muscle is relaxed, the ligament becomes tense and the lens flattens.

Constant contraction of the ciliary muscle not only tends to drag the walls of the eye towards the axis, but also by slightly compressing the contents to force the cornea and fundus further apart, and so of itself creates an axial myopia out of that which has so far been refractive.[1]

Unless the tissues in the posterior section of the eye are loosened by disease, elongation will not occur. But if the above conditions are satisfied, and softening has resulted, elongation will take place, thus causing myopia. Myopic staphyloma is a bulge which forms when the posterior pole pushes back deeper into the orbit.

Refractive myopia occurs when there is a change in the refractive power of the media. The anomalies in the refracting power causing myopia are as follows: (1) an abnormal convexity in the cornea with a consequent increase in its refraction; (2) spasm of the ciliary muscle by aid of which the lens becomes abnormally convex causing an increase in refraction; (3) the error produced by an improper curve which thereby alters the total refracting power of the media.[2]

Progress.—We can classify myopia as to the rate it might progress. If, during a period of years, the condition of myopia does not vary to any considerable degree, the condition is known as static or stationary myopia. But if the condition takes a turn for the worse and staphyloma and changes in the retina and chlorioid take place, causing an increase in myopia, we have a condition known as progressive myopia.

If the rays come to a focus before reaching the retina due to some defect which occurs after birth, the resulting condition is termed acquired myopia. This includes the influence of the rate of contraction on fatigue and the recovery of the ciliary muscle. The following is a result of a physiological experiment which I performed at Loyola University: "Upon the application of an electrical stimulus to a muscle, periods of latency, contraction, and relaxation occur. The intensity of the stimulus magnifies the magnitude of muscular response. When the strength of the electrical current is increased, the magnitude of the muscle contraction increases. By stimulating the muscle through a series of electrical shocks, the muscle fatigues because the products of oxidation in the muscle fibers are carried away more slowly by the circulatory fluid. During fatigue, the latent, contraction, and relaxation periods are all increased. The degree of relaxation decreases rapidly till partial tetanus occurs."

The muscles of convergence, through hyperstimulation and lack of relaxation periods at periodic intervals, with an increase in the amount of exudate re-

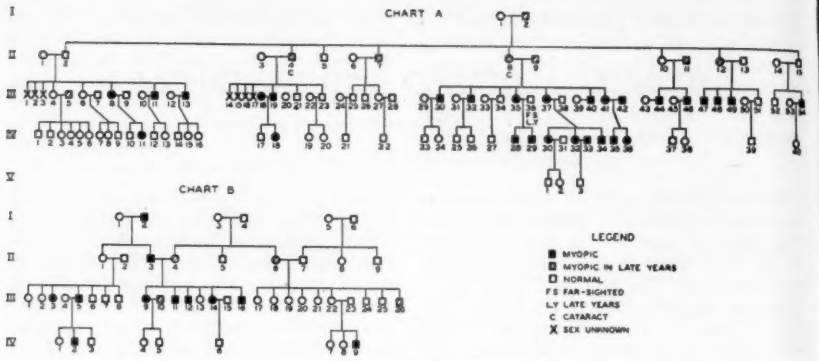

Fig. 1.—A familial study in Myopia.

CHART A—

1—the dominence of Myopia in this family is clearly shown in the third and fourth generations.

(a) 3 of 5 children (marriage of II– 1 and 2)
(b) 6 of 7 " (" " II– 8 and 9)
(c) 2 of 2 " (" " II–10 and 11)
(d) 3 of 4 " (" " II–12 and 13)
(e) 1 of 2 children (marriage of II–14 and 15)
(f) 2 of 2 " (" " III–35 and 36)
(g) 3 of 3 " (" " III–37 and 38)
(h) 2 of 2 " (" " III–41 and 42)

(1) IV–36 is the turning point of the younger children. She has just become 7 years old. IV–23, 24, 25, 26, 39, 40 / V–1, 2, 3 } are all under 6 years of age.

More definite conclusions can be drawn if these children are followed through.

CHART B—

1—follow through the generations which result from I–1 and 2. Conclusion: Myopia may be acquired and definitely may be inherited.

(a) 1 of 2 children (marriage of I–1 and 2)
(b) 2 of 7 " (" " II–1 and 2)
(c) 5 of 6 " (" " II–3 and 4)
(d) 1 of 2 children (marriage of III–4 and 5) IV—3, 4, 5, 6 are under 7 years of age.

maining in the muscle fibers, is found exactly as was described in the above physiological experiment. Functional or false myopia is thus produced and is considered the accumulative effect of several years.

False myopia is due to a hypertonicity sent to the ciliary. This causes the cilia muscles to flex or contract. This contraction causes an overconvexity of the crystalline lens, and light passing through a lens in such a condition is brought to a focus anterior to the retina. The light, by the time it reaches the retina is divergent, having crossed at the focal point in front of the retina. This is hastily called myopia,[8] although actually it is pseudo-myopia. All persons, especially children, who read a book held about 4-5 inches from the eyes, develop hypertonicity of the ciliary muscles. Because of the nearness of the book, hypertonicity of the internal recti muscles occurs, causing a convergent effort in excess to that which is necessary when the book is held the normal distance (12-18 inches) from the eyes. Accompanying the excessive convergent effort is excessive accommodation. In a short period of time, this will become a habit. The muscles go into a state of partial tetanus, and now the person must necessarily hold the book 4-5 inches from his eyes. This is a pseudo condition due to constant hypertonicity of the internal recti muscles which control convergence, and the ciliary muscles which affect accommodation. This can be relieved by resting the eyes for a short period of time; the wastes will be slowly carried away, and then the muscles will return from a state of partial tetanus to normal.

Theories.—The eye muscles are supplied by nerves from the parasympathetic (craniosacral) system. These nerves also control the visceral organs. Because of this mutual connection, a disturbance of these organs will cause the convergence-accommodation ratio to be disturbed.

This is the outstanding theory on acquired myopia.

Another causative agent is endocrine gland disturbance. The development of the secondary sex characteristics at puberty causes hormonal secretion into the blood. It is possible that this secretion would affect the ocular mechanism to cause some degree of functional myopia.

Heredity.—The eye at birth is hyperopic or far-sighted, and lacking in ciliary tonus. As development takes place, there is a physiological process of developing tonus in the ciliary muscles. Normally emmetropia is produced when the two processes are equalized, and the ciliary tonus is adjusted to focus light rays exactly on the retina. As development continues, extreme length of the eyeball or excessive curvature of the cornea may occur, thus causing myopia. These two causes are thought to be hereditary. Dr. L. H. Snyder says, "In high myopia, some families fulfill the requirements for the dependence of the trait upon a recessive gene. In those cases, it is usually found that there is undue length of the globe. In other families, the myopia is correlated with excessive curvature of the cornea, and here we find evidence that the factor for high myopia is dominant."

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EFFECTS OF TOBACCO SMOKE UPON MICE

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Bogen[1] states that under ordinary conditions many competent observers have failed to note any deleterious effects from the use of cigarettes. Also from our own general observations it would appear that moderate cigarette smoking has no bad effect in normally healthy women. However, because some women realize that it is a mother's *duty* to bear her child not only alive, but also healthy, and because smoking may have a harmful effect upon the course of pregnancy, a popular question has arisen: "What are the effects of cigarette smoking in a pregnant woman?"

Viewpoints by laymen and members of the medical profession on the numerous questions involved are decided, but yet conflicting, and are unsupported by experimental or statistical data. Upon reviewing the literature of the relatively few experiments performed in an effort to answer these questions we encountered many limitations: Primarily, the number of studies on this subject is relatively small. Secondly, the findings of the various authors are too contradictory to permit the drawing of reliable conclusions. Finally, in too many instances, the number of animals used in the experiments were too small to gain convincing results.

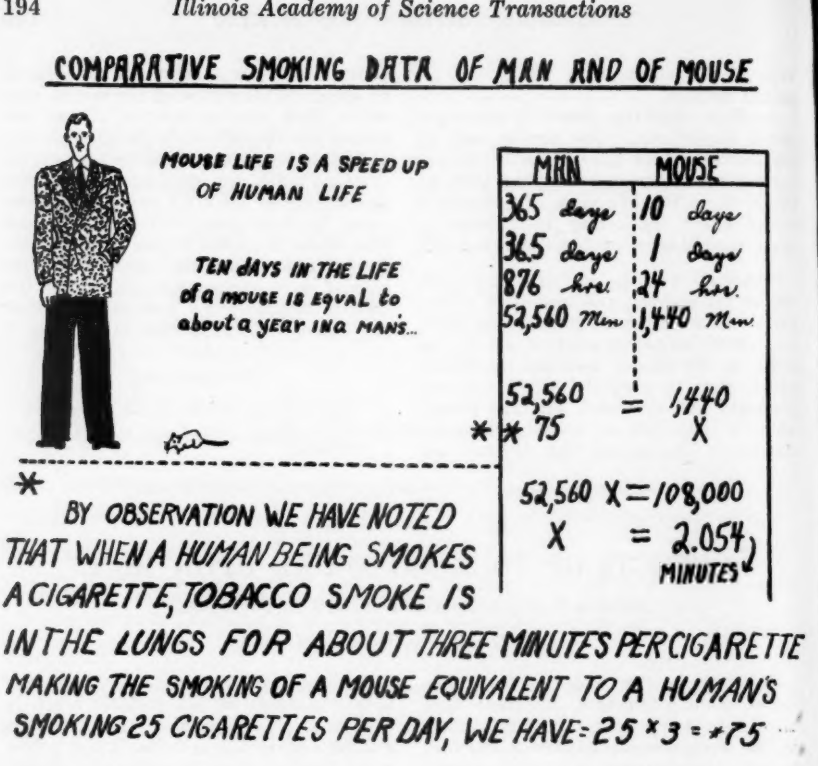
After considering all these facts the only conclusion we can possibly reach is that the tobacco problem has not been studied sufficiently, and that it may prove more serious than is generally recognized.

In most of the experiments that were performed to determine the effects of tobacco smoking, injections of pure nicotine were used. It was not intended that the effects of injected nicotine be considered the same as those of smoking, but because nicotine is the most potent poison in the tobacco leaf, it was for this reason that nicotine alone was studied. A summary of some of the results obtained by this method is as follows:

Hatcher & Crosby[2] have demonstrated that lactating mothers secrete a sufficient amount of nicotine into their milk to cause a severe case of nicotine poisoning in their offspring.

Edmunds[3] reports that young animals were more susceptible to nicotine than older ones. This susceptibility resulted in most cases in death even after very mild doses.

Allen, Behrend, & Thienes[4] have found that while "control" animals showed an abundance of subcutaneous and intraperitoneal adipose tissue, the nicotine injected


COMPARATIVE SMOKING DATA OF MAN AND OF MOUSE
MOUSE LIFE IS A SPEED UP OF HUMAN LIFE
TEN DAYS IN THE LIFE of a MOUSE IS EQUAL to about a YEAR IN a MAN'S...
MAN
MOUSE
365 Days 10 Days
365 Days 1 Days
876 hrs. 24 hrs.
52,560 Min 1,440 Min
52,560 = 1,440
* 75 X
52,560 X = 108,000
X = 2.054 MINUTES
BY OBSERVATION WE HAVE NOTED THAT WHEN A HUMAN BEING SMOKES A CIGARETTE, TOBACCO SMOKE IS IN THE LUNGS FOR ABOUT THREE MINUTES PER CIGARETTE MAKING THE SMOKING OF A MOUSE EQUIVALENT TO A HUMAN'S SMOKING 25 CIGARETTES PER DAY, WE HAVE: 25 x 3 = *75

animals showed only a scanty amount of it. "Controls" of both sexes had as much as two times the amount of fat as did the nicotine injected animals. However, *Dixon & Lee*[5] because of experiments carried on at the University of Minnesota were opposed to the idea that nicotine had any effect upon the weight of the animals.

According to *Hazel E. Fields*[6] of Occidental College, California, who used the "smoking" technique exclusively, it was learned that experimental animals weigh less on a greater food intake, and that tobacco smoke apparently did not decrease skeletal growth in young animals fed with an adequate diet. The adrenal glands of the smoked animals showed a very noticeable increase in weight probably due to hypertrophy resulting from the oft-repeated, slow absorption of nicotine in minute amounts from the musoca of the mouth and respiratory tract. Also, Miss Fields states that it is extremely unlikely that continued stimulation of adrenal medulla and cortex would not exert a considerable influence upon at least the pituitary and gonad.

Perhaps the most conclusive results thus far obtained in work on pregnant animals were obtained by *Dr. Essenburg*[7] of Loyola University Medical School, Chicago. When performing his experiment he used at least *seven* times as many more animals as did any of the previously mentioned experimenters. He used not only the nicotine injection technique, but also a smoking technique, after which our experiments were patterned. He noted that:

Two thirds of all the young of treated mothers were underweight; the young from the nicotine-injected mothers being more underweight than those from the smoked mothers. This underweight group remained underweight during the entire period of observation, and many were not only underweight, but also died early.

Of the females injected, 63.3% lost one or more young before weaning, and 33.3% lost all of their young.

Of the mothers exposed to tobacco smoke 28% lost one or more of their young before weaning, and 13.5% lost all of their young.

Of the mothers smoked prior to mating but not during pregnancy, 23.3% lost one or more of their young before weaning, and 25% were underweight. In both groups of the treated mothers, temporary sterility, resorption of young in utero, and abortions were noted.

Dr. Gerd Umbehaun, an eminent German physician, by way of observation in his many years of practice had noted that women who smoke have lessened secondary sexual characteristics.

At Loyola University, Chicago, we are endeavoring by experiment to observe the effects of cigarette smoke on mice. We had chosen mice primarily because they were very readily available and because of their rapid reproduction and development. Our experiments are planned to:

1. Observe the effects of cigarette smoke on female mice from the time that they become independent of the parent, through their developing stages to adulthood, during pregnancy, and the consequent effect on their offspring.

2. Observe the effects of cigarette smoke on male mice from the time that they become independent of the parent, through their developing stages to adulthood, noting especially their fertilizing ability and sexual instincts while being treated.

3. Although the above mentioned two are our primary interests, certain other observations incidental to the experiment have been, and will be recorded.

Some of the observations made during the short period of time this experiment has been in progress, agree in part with the observations made by experimenters using the nicotine-injection technique. Before stating some of our observations, those resulting from the nicotine-injection technique are: excitations or convulsions, dyspnea accompanied by gnashing teeth, stiffening of the hind legs and tail, and other general reactions indicating a reduced threshold of irritability.

Regarding our experiment, the mice when in the smoking chamber were in general quiescent, seeming to avoid deep respiration by decreased activity. Only on few occasions, toward the latter part of the smoking period, were the mice seen to make an effort to get out of the smoking chamber. For the first few smokings the animals were known to have slight nasal inflammation and teary eyes, assumingly because the smoke was especially irritating. Although the stools were of the same general appearance and there was no outward evidence of gastro-intestinal disturbances increased defecation occurred, but gradually decreased as the animal became more accustomed to the smoke. Sexual interest and instinct does not express itself during the smoking and immediately following the smoking. A seemingly painful breathing, accompanied by slight wheezing noises, becomes noticeable toward the end of a smoking. Contrary to the results obtained by Miss Fields of Occidental College, California, who noted that both qualitatively and quantitatively the smoked animals were more active for a period of 15 minutes to 1½ hours following a smoking, we have noticed that the smoked mice remain exceedingly inactive during the period immediately following the smoking. During this period, sexual interest is lacking, and the desire for food, in spite of their hunger, is lacking. Throughout this entire period the mouse lies on its ventral surface, breathing at a normal rate, but showing a very reduced threshold of irritability.

Up to date three rather unique reactions were given by three experimental animals—two females, one of which was pregnant at the time, and one male. After 10 and 9 smokings respectively, the animals fell into a state of convulsion lasting from 2 to 5 minutes, during the early part of which there was no reaction to stimuli, and a temporary paralysis of the entire pelvic region took place. During the recovery period, as the animals made an effort to walk, progress was made in a lateral rather than a forward direction due to the position of the hind limbs clasped in paralysis.

While it can always be said that results obtained upon one animal form cannot be transferred to another, nevertheless definite results obtained in the mouse have a very high probability of holding true in some degree for man. By means of a system devised by my colleague, Kenneth Fitzgerald, we have determined the length of time a mouse would have to be subjected to smoke in order to bring about effects which would be equivalent

to effects produced in a human who smokes twenty-five cigarettes a day. See figure 1.

The moist surfaces, such as the hair under the mouth which frequently become wet with saliva, tend to collect the particles in the smoke. The mice ingest these substances in their vigorous cleaning processes following the smokings. Therefore, we may say that the animals may actually swallow as much of the material as does the human smoker when his mouth is in contact with the pipe or the cigarette. However, again we have absolutely no quantitative means of comparison here.

You may wonder whether our dosage and mechanical smoking technique adequately imitates human's smokings. Although this is a debatable question the factors involved justify our making an analogy between mice and men. In ending, may we once again emphasize the fact that we realize the results obtained on mice cannot be transferred *directly* to the human, but the essential results obtained will challenge our own reconsideration of the problem.

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